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THE RELATIVE VALUE OF CATGUT, SILK, LINEN, AND COTTON AS SUTURE MATERIALS

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A LARGE number of investigations have been reported concerning the relative value of silk and catgut as suture materials and with few exceptions these demonstrate the superiority of the former over the latter. Because there had been no comprehensive comparative appraisal of a large number of suture materials, the present study was undertaken in order to evaluate the efficacy of catgut, silk, linen, and cotton.

Undoubtedly, today the average physician fears nonabsorbable suture because "foreign bodies" have been emphasized by pathologists and older surgeons as detrimental and this has deterred him from using nonabsorbable materials. This fear has been justified by the poor results which have been obtained but which were due to the incorrect use of the nonabsorbable suture. Unquestionably the experience of Lister,[1] whose opinion was highly regarded, greatly influenced the surgical world in rejecting nonabsorbable sutures. It was unfortunate that Lister's earliest experience with silk led him to conclude that it predisposed to infection. This belief was based upon finding, in one of his early cases, a localized collection of cloudy fluid surrounding a silk ligature ten months after ligation of a vessel for aneurysm. It remained for Kocher[2, 3] and Halsted[4] in the 1880's to demonstrate the superiority of silk over catgut. If the tenets of Halsted laid down a half century ago had been adhered to, little difficulty would have been experienced with nonabsorbable sutures. Whereas practically all of the men trained by Halsted use silk routinely in clean wounds, it remained for Whipple,[5] who had previously used only catgut, to popularize the use of silk.

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The numerous methods of treating and of sterilizing catgut, its variability of absorption, and the frequent charges by surgeons that catgut was responsible for infections, led Bulloch and co-workers[6] to make a thorough investigation of the preparation and sterilization of this suture material. They found that there were only two chemicals which produced sterilization of catgut; namely, hydrogen peroxide and iodine. They also found the heat sterilization process of Krönig to be excellent. Krönig's[7] method consisted of drying the catgut at 70° C. for two hours, then placing it in cumol, a hydrocarbon (boiling point 153° C.), and heating it for one hour at from 155 to 165° C. One of the most extensive investigations is that of Minervini,[8] who showed that dry heat is of questionable value as bacterial spores proved resistant and were not destroyed at less than 140° C. for three hours, and that prolonged heating at this temperature greatly reduced the tensile strength and pliability of the suture material. Obviously, pliability is essential as the tensile strength greatly decreases when a knot is tied in stiff material. Considerable credit is due Meleney and his associates[9, 10] in pointing out the possibility of wounds becoming infected from supposedly sterile catgut sutures. Meleney's interest was aroused by the occurrence of gas gangrene in five patients whose wounds should have been clean. Clock[11, 12] in a recent publication showed that of the American manufactured catgut several brands were not sterile. In 1930, 1931, 1932, and 1934, seven brands were sterile and five brands were not. In 1933, eight brands were sterile and four were not. Shambaugh,[13] in analyzing 2,360 inguinal herniorrhaphies, showed the incidence of suppurative wounds to be twice as great following the use of catgut as that following silk. In contrast to the difficulty in sterilizing catgut, sterilization of nonabsorbable suture materials can be readily accomplished.

It has been the opinion of most surgeons that the persistence of a suture after wound healing is detrimental and that in the presence of infection it alone is responsible for continuation of the infection. Because of this, catgut, which is absorbable, has been the most popular suture material. The absorbability of catgut is influenced by a number of factors as emphasized by Howes and Harvey.[14] Hemorrhage, tissue necrosis, infection, and that unknown factor, a man's personal constitutional reaction to protein, all increase the rapidity of absorption. Frequently, it has been observed by us and by many others that as early as the seventh day postoperatively no evidence of twenty-day chromic catgut in the wound can be demonstrated. Whereas increased absorbability of catgut has been explained on the basis of allergic manifestations, especially by Kraissl, Keston, and Cimiotte,[15] carefully controlled investigations by Pickrell[16] tend to disprove this.

Wound healing in the presence of catgut is definitely retarded, as has been shown by Kocher,[3] Halsted,[4] Whipple,[5] Shambaugh,[13] Howes

and Harvey,[14] and by us. The effect of catgut on the healing of wounds has been well described by Howes,[17] who showed that with plain catgut there is swelling of the strand with a zone of polynuclear leucocytes at the periphery and in the interstices. This process becomes progressively more marked up to the fourth day when mononuclear leucocytes appear. Fibroblasts then grow out and penetrate into the interstices of the suture. In the meantime, the cross section of the strand decreases and the suture is completely absorbed in from four to seven days, depending upon the size of the suture. Chromic catgut swells less, but fibroblastic proliferation begins twenty-four to forty-eight hours later. Here again absorption depends upon the size of the suture but is usually complete in from nineteen to twenty-three days. According to Howes,[17] the coaptation of the wound is entirely dependent upon the suture for a period of four days, at which time fibroblasts begin to proliferate and assist in holding the wound. Fibrosis does not reach its maximium for from twelve to fourteen days.

The chemicals used in the preparation of catgut, chromic acid salts, iodine, copper, formalin, and tannates are all deterrents to dry wound healing. These chemicals, in addition to the animal protein, produce an inflammatory reaction characterized by increased exudation which Gage[18] has termed a wet type of healing; whereas, silk, linen, and cotton produce little inflammatory reaction, thus resulting in a dry type of healing which is associated with early fibroblastic proliferation. For many years we have demonstrated to our house officers the comparative reactions of the skin to catgut and to nonabsorbable sutures by closing one-half of the wound with catgut and the other half with a nonabsorbable suture. The inflammatory reaction about each catgut suture site, consisting of redness and a seropurulent exudate, is a distinct contrast to the lack of reaction surrounding the nonabsorbable suture. It is an established fact that wound healing is retarded in the presence of infection. As previously demonstrated by Shambaugh[13] and Whipple[5] and corroborated by us, infection is much more likely to occur in the presence of catgut than when nonabsorbable sutures are used. We have repeatedly observed grossly contaminated wounds closed by interrupted nonabsorbable sutures heal per primum.

Huhne[19] has pointed out that when catgut swells it shortens, and when shortened it may break. It may untie the knot or it may break at the knot. Taylor[20, 21] demonstrated experimentally that the knot, the suture immediately adjacent to the knot, and the sites of kinks were the weakest points in the tied suture. We have corroborated these observations and those of Howes,[17] who found that a wound closed with catgut is weakest between the fourth and the eighth days due to a considerable decrease in the tensile strength of the catgut and insufficient lapse of time for fibroblastic strengthening of the wound. It is only after the eighth day that the wound becomes as

strong as the surrounding tissue. According to experiences of those (Sokalov,[22] Hesse,[23] Radlinski,[24] and Traczak[25]) who have seen and analyzed a large number of them, wound disruptions usually occur between the fifth and the twelfth days and most frequently between the seventh and ninth. Ries[26] and Fallis[27] have reported disruption as early as the second day and even then were unable to demonstrate catgut in the wound.

SILK

Silk should be classed as a nonabsorbable suture, although it is mainly protein.[28] It is pliable, easily sterilized, and, when not serum-proofed or waxed, contains no chemical other than an iron dye. Silk consists essentially of a center or core of fibroin, with a covering of serecin or silk albumin and a little waxy material. Fibroin, which is analogous to horn, hair, and similar dermal products, constitutes from 75 to 82 per cent of the entire mass. Silk is spun as a fine fiber 800 to 1,200 m. long. It is insoluble in water, alcohol, and ether, but dissolves freely in concentrated alkaline solutions, mineral acids, strong acetic acid, and ammoniacal solution of copper oxide. Silk is highly hygroscopic and, when heated to 120° C., will lose from 10 to 15 per cent of its weight in moisture. Microscopically, the silk strand is round and straight. Silk used in spinning thread is devoid of serecin or its gummy portion, due to its being boiled off in a solution of soap, following which the silk is washed until all of the alkali is removed. At this stage, the silk, which is to be white, is bleached in sulfurous acid fumes and then washed in distilled, cold water until the acid is removed. As considerable weight is lost in the boiling-off or scouring process, the addition of tin salts, usually $SnCl_4$, is sometimes made. The stannic chloride acts as a mordant so that the silk can take a black dye. Another method used in dying silk black consists of the use of nitrate of iron, fustic, hematine, and soap. Finally, the silk is washed until the soap is thoroughly removed.

Whereas silk is mentioned in some of the earliest medical writings, by Celsus, Galen, and later Trotula (A.D. 1050),[29, 30] it was not until 1888 that silk came into more general use because Kocher[31] had so many infections with catgut. From May to July, 1887, there occurred twenty-nine serious infections in thirty-one operative wounds on Kocher's wards. These he attributed to catgut and forthwith turned to silk. About the same time W. S. Halsted[4] in this country began to use silk in all clean wounds. Halsted's technique varied somewhat from that used in Kocher's clinic. These variations consisted principally in the use of fine silk in preference to coarse silk and the use of interrupted rather than continuous sutures. Halsted,[4] in 1913, emphasized that good results were being obtained in wounds closed with silk in the German clinics even though rubber gloves were not used. The tenets

of Halsted[4] are as true today as when first enunciated by him in 1893. He advised: "(1) The use of interrupted sutures only, (2) the use of silk not coarser than C, (3) to never bridge over a dead space as a chord subtends an arc, (4) to use transfixion suture in ligation as finer material could be used this way, (5) to use a greater number of fine stitches rather than a few coarse ones, and (6) to avoid the combined use of silk and catgut." As Homans has said: "In surgery, however, as in every other Art, fundamental matters are perennially being discovered, discredited, forgotten, rediscovered, and reaffirmed." Thus it is with Halsted's simple observations on the use of silk suture material. Practically all Halsted-trained men use silk and are staunch advocates of the employment of this material. More recently Whipple,[5] Shambaugh,[13] Babcock,[32] and others have advocated the use of nonabsorbable sutures. All, with the exception of Babcock, advocate the use of silk. Howes and Harvey[14] in a study of tissue reaction and wound tensile strength demonstrated microscopically that silk produced less inflammatory reaction in the tissue than catgut. The wound healed earlier and the tensile strength of the wound increased more rapidly as the fibroblastic reaction was greater and earlier than that associated with catgut. The silk soon became encapsulated in a fibrous sheath. As Shambaugh[13] states, catgut may act as a nidus of infection, and we believe that the poor results obtained from the combined use of silk and catgut are due to a nidus of infection and increased tissue reaction produced by the catgut. Whipple[5] showed that, by the use of silk in a period of three years, serious wound infections were reduced from 1.9 to 0.7 per cent and trivial infections from 8.9 to 1.5 per cent in supposedly clean wounds. Shambaugh and Dunphy[33] in experimental work on animals showed that silk wounds better tolerated slight bacterial contamination because silk was less irritating to the tissue than catgut. However, as we shall point out again, when a continuous silk suture is used in the presence of infection, a sinus frequently results.

Silk is easy to handle because, with the exception of cotton, it is the most pliable of all suture materials. One who has been trained in the use of catgut, however, as Halsted noted, will find some difficulty for a few months in becoming accustomed to this material. There is a tendency for the novice to break it, but, when this occurs, the suture or ligature is being tied too tightly and tissue strangulation would be bound to occur.

The bacterial content of unsterilized silk has apparently received little attention, although Konrich[34] and Goris[35] described with considerable detail its sterilization. This phase will be mentioned and discussed later.

Whereas untied chromic catgut has greater tensile strength than silk, the latter is still stronger than the tissue in which it is placed

and, as compared to catgut, remains so throughout the period of healing. However, as will be pointed out in the experimental work, there is greater decrease in the tensile strength of silk than is commonly thought. Silk, though smooth as catgut, has a greater tendency to cut tissue, but this may be due to excessive constriction of tissue. In addition to producing an occasional persistent sinus in the presence of infection, silk may produce a still more infrequent complication, which, although not described in the English literature, has appeared in the Continental literature. This complication is a low grade inflammatory tumor described first by Schloffer[36] in 1908. The tumor may occur from months to years after the implantation of the silk and is cured by the removal of the silk from the center of the tumor. Whipple[37] suggests that the tumor is the result of the use of too heavy silk. As these tumors have been removed as late as seven years following the implantation of the silk, it demonstrates conclusively that for practical purposes silk is nonabsorbable. We have observed two cases which were due to the incorrect use of silk before we learned to use it properly. These will be described later.

LINEN

Linen is derived from flax. Whereas flax is grown in France, Russia, Ireland, and other Middle European countries, Coutrai flax of Belgium is best, due to its strength and fineness. Belgium flax contains 52 per cent cellulose, 4 per cent extractive matter, 8.5 per cent water, 2.4 per cent fat and wax, 2.7 per cent intercellular substance, and 0.7 per cent ash. The fibers range in length from 20 to 140 cm., with an average breadth of 0.016 mm. The resinous and gummy material is largely removed by benzine prior to bleaching and the greater the bleach the less the resinous material. Fibers which are to be used for thread receive the greatest bleach.

Antyllus (A.D. 200),[29] who first attempted to cure an aneurysm with a ligature, used linen and sometimes catgut. In the thirteenth century Berlapoglia Leonardo recommended linen as a suture material. Since the time of these early writers, linen has been used as a suture material with more or less success. About 1865, Pagenstecher, a German ophthalmologist, prepared linen by treating it with a celluloid solution. This made a much more pliable suture, giving considerable less friction and less serum absorption. This suture has been used many thousands of times as a purse-string suture in appendectomies, and during the World War was used extensively by the German army surgeons[38] because of the scarcity of catgut. Apparently it has been a very satisfactory suture.

COTTON

Cotton, one of the most important vegetable fibers, is readily available as suture material in the form of ordinary thread. It is inexpen-

sive, pliable, fine, and, as will be shown, is easily sterilized. Cotton, a cellulose material, consists of unicellular hairs which occur attached to the seed of various species of plants of the genus Gossypium, belonging to the Malvaceae. Each fiber is formed by the outgrowth of a single epidermal cell of the testa or outer coat of the vessel. Microscopic examination of the mature cotton shows that the hair is twisted and flattened. This characteristic is of considerable technical importance, the natural twist facilitating the operation of spinning the fibers into thread or yarn. It also distinguishes it from silk and linen which have no natural twist and consequently have more of a tendency to fray out. Cotton thread is made from the long fiber Egyptian or Sea Island cotton. When spun, it is usually made up of six cords which do not become unraveled as easily as twisted silk or linen. In addition to the plain cotton there is a mercerized thread. The latter, as will be shown, is somewhat stronger, size for size, than the plain thread, although it contains but three cords. The process for its production was devised by Mercer in 1813 and consists essentially of putting cotton thread in a warm 25 per cent solution of potassium hydroxide for an hour, which produces a quick shrink and at the same time a glossy sheen. Following the immersion in the alkali, the cotton is either washed in running water until neutral or the alkali is neutralized by acid. When finished, the pH of the mercerized thread varies between 6.8 and 7.2.

In the year 500 B.C. Susruta[28] recommended the use of sutures in wounds of the abdomen and of joints. For suture material he used cotton, strips of leather, plaited horsehair, and animal tendons. This is the only mention of cotton as a suture found in ancient literature. Recently, in 1936, Ginkorski[39] published an article on the use of cotton as a suture material. He advised using Nos. 30 and 40 spool cotton which has been cold sterilized in a mixture of 8 per cent formalin and 5 per cent tannin solution. The sterilizing solution has been previously injected into animals subcutaneously and intramuscularly and apparently caused a painless swelling which rapidly disappeared. Besides getting good results in 100 animals, Ginkorski operated upon twenty-three human beings, using cotton throughout, with healing by first intention.

Although cotton has been used as a ligature material by Gage,[18] of Tulane University, and by Guerry, of Columbia, S. C., it has not been used for the major portion of their surgery. However, the experimental and clinical uses of this material were encouraged by seeing Gage use it frequently as a ligature.

EXPERIMENTAL INVESTIGATION

In order to determine the relative efficacy of catgut, silk, linen, and cotton as suture materials the following experiments were performed:

I. Tensile strength

The tensile strengths of the various sizes and types of cotton, catgut, silk and linen were determined:

1. On straight and knotted unsterilized, ordinary spool cotton, silk, and linen
2. On cotton, silk, and linen sterilized by boiling for varying lengths of time; sterilized by autoclaving in steam alone and in oil
3. After cotton, catgut, silk, and linen were allowed to remain in animal tissue (rabbit) for varying lengths of time

II. Tissue reaction and wound healing

The gross and microscopic reactions of tissue (rabbit) to catgut, cotton, silk, and linen were determined and compared.

III. Bacteriology.

The bacteriology of cotton, silk, and linen was studied.

1. Prior to sterilization
2. Following the destruction of the ordinary pyogens
3. Following boiling
4. Following autoclaving

Tensile Strength.—To determine the tensile strength (break strength) of sutures, a simple, frictionless method was used. The apparatus consisted of a ring stand and tubular crossbar. Approximately 60 inches of the material to be tested were wound around the crossbar. The free end of the suture was then attached to a weight holder, being wound around the cylindrical hook at the upper end. Weights, 100 gm., 50 gm., and 25 gm., increments were added every fifteen seconds until the suture broke. The length of the suture tested in each instance was 4 inches. When the suture broke, 8 inches of the remaining material wound around the crossbar were discarded before the next determination. The stretch was not recorded regularly with silk, cotton, and linen as it was insignificant (less than 2 mm. per 100 gm.); whereas, with catgut the variation in the stretch in the same suture was so great than an average could not be arrived at. Four determinations were made on each size suture, except that with catgut, six determinations were made as there were greater variations in the break strength.

To determine the effect of knotting on the different sutures, a square knot was tied in the middle of a straight suture, and in another piece of the same material the free ends were approximated with a square knot and the break strength noted (Table I).

Size for size, dry catgut is the strongest suture material, with silk, linen and cotton following in order. Twisted black silk, which had not been serum-proofed and designated by Manufacturer A as "surgical silk" is 25 per cent stronger than cotton of the same size (Fig. 1).

There is very little difference in the tensile strengths of linen and silk. White mercerized cotton, while only a three-cord thread as compared with the six cords in ordinary thread, has a 10 per cent greater tensile strength, due to the shrinking by mercerization. Following boiling there is 11 per cent increase in the tensile strength of cotton, 15 per cent in linen, and 4 per cent in silk (Fig. 2). Catgut was not subjected to boiling for obvious reasons. Furthermore, it was found

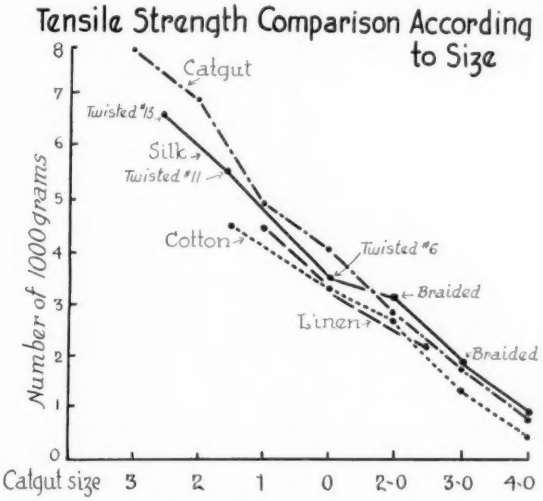

Fig. 1.—Graph illustrating tensile strength of various suture materials according to size.

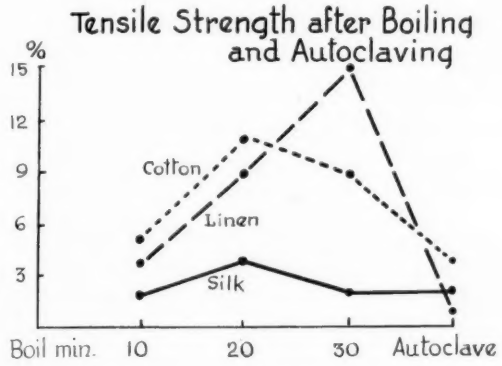

Fig. 2.—Graph illustrating tensile strength of various suture materials after boiling and autoclaving.

from the standpoint of tensile strength that twenty minutes was the optimum length of time for boiling silk and cotton, and thirty minutes for linen (Table I). Steam autoclaving for fifteen minutes at fifteen pounds of pressure, produced little change in the tensile strength of any of the sutures, but any increase in the time and pressure caused a definite decrease in strength. Autoclaving in oil produced a 2 per cent decrease in strength in all sutures. There was less decrease in

TABLE I*

NO.	PHYSICAL STATE OF SUTURE	UN-STERILE	BOILED 10 MIN.	BOILED 20 MIN.	BOILED 30 MIN.	AUTO-CLAVED	OIL AUTO-CLAVED	IMPLANTATION IN TISSUE			REMARKS
								4 DAYS	7 DAYS	14 DAYS	
12 Cotton	Straight	2050	2135	2245	2175	1930	1860				
	Knotted	1200	1400	1425	1300	1160	1400				
24 Cotton	Straight	1550	1600	1690	1700	1490	1475				
	Knotted	1000	950	1100	1080	1000	1100				
30 Cotton	Straight	1420	1610	1775	1750	1420	1500	1640	1600	1400	
	Knotted	1000	1070	1160	1280	950	1180				
50 Cotton	Straight	880	960	975	940	850	860	925	930	890†	
	Knotted	770	660	670	700	580	770				
60 Cotton	Straight	780	780	810	840	820	720				
	Knotted	660	535	575	575	535	575				
80 Cotton	Straight	720	770	780	780	720	760				
	Knotted	600	480	535	480	500	520				
Mercerized heavy duty	Straight	1360	1375	1360	1320	1360	1300				
	Knotted	1050		960	910	900	970				
20 Mercerized crochet	Straight	2750		2875		2725	2750				
	Knotted	1780		1840		2030	2000				
10 Mercerized crochet	Straight	3420	3500	3550	3500	3550	3475				
	Knotted	2200	2350	2350	2350	2300	2400				
5 Mercerized crochet	Straight	4450	4470	4650	4700	4650	4620				
	Knotted	2720	2700	2750	2800	2600	2700				
30 Black cotton	Straight	1380		1550		1500	1470	1460	1450	1390	
	Knotted	1000		1190		1075	1200				
50 Black cotton	Straight	875		950			880	930	940	910	
	Knotted	690		690			750				
50 Mercerized plain	Straight	1160	1070	1070	1060	1000	1040				
	Knotted	640	650	640	655	555	670				

*All figures in grams.

†In human split graft 18 days; tensile strength, 800 gm.

1 Deknatel silk	Straight Knotted	1850 1270	1950 1250	1920 1300	1850 1250	1920 1270	1800 1300				
2 Deknatel braid silk	Straight Knotted	3150 1900	3350 1960	3220 1950	3120 1900	3270 1920	3150 2350	2450	1900	2100	
6 Twisted silk	Straight Knotted	3000 2050	3150 2100	3150 2150	3000 2000	3200 2250	2950 2300	2370	1650	1700	
9 Twisted silk	Straight Knotted	3500 2375		3600 2400		3650 2400					
18 Twisted silk	Straight Knotted	5500 2900									
15 Twisted silk	Straight Knotted	6500 3900									
60 Linen thread	Straight Knotted	2200 1200	2340 1350	2410 1200	2650 1480	2600 1450	2350 1580				
30 Linen thread	Straight Knotted	4050 2150	4200 2250	4430 2500	4600 2750		4000 2600	3180	2830	2550	
4-0 Chromic catgut	Straight Knotted					915 595		590 (2d)	600(5d)†	340(9d)†	Factory sterilized; 5 cm. stretch before breaking
3-0 Chromic catgut	Straight Knotted					1700 950		900 (2d)	850(5d)	500 (9d)	Factory sterilized
2-0 Chromic catgut	Straight Knotted					2850 1600					Factory sterilized
0 Chromic catgut	Straight Knotted					4050 2350					Factory sterilized
1 Chromic catgut	Straight Knotted					4950 3150					
2 Chromic catgut	Straight Knotted					6800 3975					
3 Chromic catgut	Straight Knotted					8100 4800					

the tensile strength of the oil-autoclaved sutures when knotted as compared to steam-sterilized sutures.

As can be seen from the graph (Fig. 3), there is a marked loss in the tensile strength of all sutures when knotted, and, as Taylor[20, 21] has pointed out, aside from the knot itself, that portion of the suture immediately adjacent to the knot is the weakest section and, when tied properly, the suture invariably breaks here. Angulation with

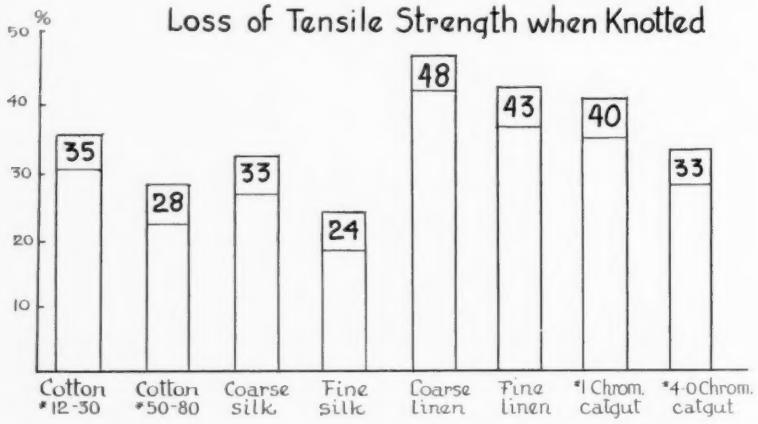

Fig. 3.—Graph illustrating loss of tensile strength of various suture materials when knotted.

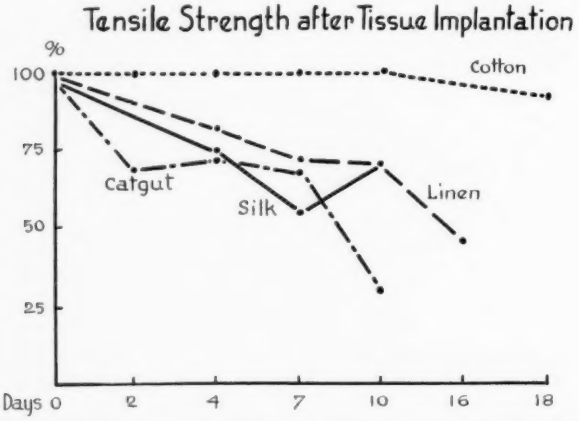

Fig. 4.—Graph illustrating change in tensile strength after tissue implantation.

cracking of the fibers or friction of the sawing action of the two fibers in tying a knot in a catgut suture may so fray the catgut that breaking will occur in that area and not adjacent to the knot. Furthermore, the larger the suture, the greater is the decrease in the tensile strength when knotted (Fig. 3).

The tensile strengths of various suture materials after being placed in tissues were determined. Sutures to be tested were placed under sterile precautions in the fascia and muscles of the anterior abdominal

wall of rabbits and were removed after two, four, seven, ten, and fourteen days respectively. Following removal they showed a decrease in tensile strength, except that the tensile strength of the cotton remained practically the same as that of the original suture (Fig. 4). There was a loss of tensile strength in linen of 21 per cent in four days, 30 per cent in seven days, and 40 per cent in ten days; in chromic catgut 30 per cent in four days, 50 per cent in seven days, and 60 per cent in ten days; in silk 20 per cent in four days, 50 per cent in seven days, and 41 per cent in ten days (Fig. 4). A large number of determinations were made in checking the strength of catgut because there was considerable variation due to stretching (this was not elasticity as there was no return to the original length). Because of the marked stretch of catgut which has been subjected to the action of tissue juices, this suture becomes relatively less efficient than nonabsorbable material. It is obvious, therefore, that not only the relatively greater decrease in tensile strength of catgut subjected to tissue juices, but also the increased stretch of this material make it less desirable as a coaptating suture. It is significant that silk buried in tissue for ten days showed a consistently greater tensile strength, following the initial drop, than that buried for seven days. This increased strength is probably due to the ingrowth of connective tissue into the interstices of the silk.

A cotton suture, No. 50 plain thread, remaining in human tissue (split skin graft) for a period of eighteen days showed only a 10 per cent loss in strength.

Tissue Reaction and Wound Healing.—The tissue reaction, fibroblastic proliferation, and final wound healing were determined as follows: plain, fine, and chromic catgut, fine and coarse silk, fine linen, fine and coarse, plain and mercerized cotton were placed simultaneously in the cutaneous, subcutaneous, fascial, and muscular tissues of the abdominal wall of rabbits and were removed twenty-four, forty-eight, and seventy-two hours, the fifth, eighth, tenth, and thirteenth days after their implantation. All the above mentioned sutures were placed in each rabbit to eliminate variations in individual tissue reaction. Before removal, a gross inspection of the tissue was made and the changes noted. Following removal, the excised wounds were placed in 10 per cent formalin and after the usual preparation were cut and then stained with hematoxylin and eosin.

On gross examination there were insignificant changes before forty-eight hours.

Forty-Eight-Hour Examination.—Catgut: There were moderate inflammatory reactions in the cutaneous tissues about both plain and chromic catgut, the latter being somewhat more pronounced than the former. The edema was much greater than that surrounding silk and

the surrounding tissue with considerable serum. There was some infiltration of the suture with wandering cells, somewhat more marked at the periphery, and the reaction was considerably greater than that about coarse cotton and silk. The capillaries were filled with polynuclear leucocytes. No collagen fibrils could be seen, but fibrin was present throughout.

Forty-Eight-Hour Examination (Fig. 6).—*Plain Cotton:* There was greater polynuclear leucocytic infiltration than in the twenty-four-hour specimen with small surrounding vessels containing polynuclear leucocytes. The suture was fraying and the polynuclear leucocytes were in the interstices. There was some necrosis with polynuclear leucocytic infiltration particularly marked at the site of cutaneous penetration. No bacteria were visible. *Chromic Catgut:* Due to the marked reaction of the tissue to the catgut, there were adhesions of the gut to the area of suture, although it did not penetrate the peritoneum. There was a marked polynuclear leucocytic infiltration with considerable serum. The blood vessels contained many polynuclear leucocytes. Collagen fibrils were not seen. *Fine Silk:* There was moderate polynuclear leucocytic infiltration in the fascia and muscle. It was somewhat more marked in the dermis. The interstices were filled with neutrophilic polynuclear leucocytes. A few collagen fibrils were present. Bacteria were not visible. Round and plasma cells were occasionally seen. The surrounding tissues were infiltrated somewhat more freely than that about the cotton. *Coarse Silk:* There was moderate polynuclear infiltration, somewhat more prominent than in the twenty-four-hour section and also greater than seen about the fine silk. Collagen fibrils could be seen easily, but were few in numbers. Bacteria were not seen. *Fine Cotton:* There was a very slight increase in the cellular reaction over the twenty-four-hour specimen. The cells were mainly polynuclear leucocytes and were sharply localized about the suture. A few cells were penetrating the interstices of the fibers. Collagen fibrils were prominent and no bacteria were visible. *Black and Mercerized Cotton:* The reaction was indistinguishable from that about the fine cotton suture. *Linen:* The wandering cell reaction was markedly greater than in the twenty-four-hour specimen. Otherwise there was no change.

Seventy-Two-Hour Examination.—Plain Catgut: The cellular reaction extended deep into the tissues. The surrounding blood vessels still contained polynuclear leucocytes, but in the tissues there was about an equal number of round cells. In some areas the suture was somewhat broken up and in others it was still intact. The wandering cells did not extend into it except where the suture had begun to disintegrate. An occasional collagen fibril could be seen, but no fibroblasts could be made out. *Chromic Catgut:* There was an even greater cellular reaction than that about the plain gut with a predominance

of polynuclear leucocytes. There was considerable serum present, but no colonies of bacteria could be seen. The cellular reaction extended for a considerable distance into the surrounding tissues; however, it tended to be less in muscle and loose areolar tissue than in the skin. There was an occasional collagen fibril, but no fibroblastic proliferation could be made out. *Fine Silk:* There was considerable cellular reac-

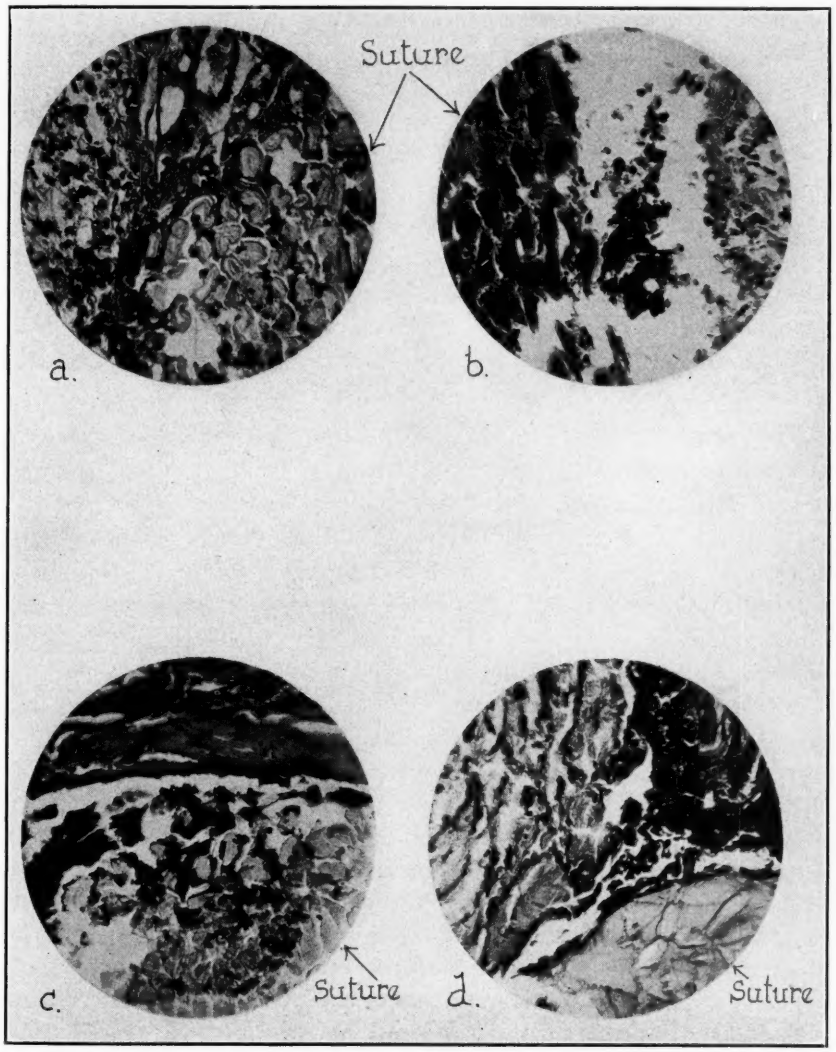

Fig. 6.—Photomicrographs of sutures implanted in tissue (rabbit) for forty-eight hours.

a, Coarse cotton (No. 30); slight increase in polynuclear leucocytic infiltration as compared to the twenty-four-hour specimen. There is a small amount of serum present. A few round cells can be seen. *b*, Coarse silk (No. 6 twist); moderate polynuclear leucocytic infiltration with considerable fibrin and many leucocytes in its interstices. *c*, Fine linen; marked increase in the polynuclear infiltration in tissues and suture with a large amount of serum in the interstices of the suture. *d*, Plain catgut (Nos. 3 to 0); increase in the polynuclear infiltration of tissues as compared with twenty-four-hour specimen. There is continued fragmentation of the suture.

tion and, although the predominant cell was of the round type, there were still many polynuclear leucocytes to be seen in the interstices and at the periphery of the silk. There was a small amount of serum present. Collagen fibrils were numerous and there was beginning fibroblastic proliferation. *Coarse Silk:* There was slightly more reaction than that about the fine silk. There was considerable collagen and serum present. There was a marked decrease in the cellular reaction, the predominant cells being of the plasma and round types. Collagen fibrils were dense and there was beginning fibroblastic development at the periphery. *Coarse Cotton:* There was about the same amount of cellular reaction as with the fine suture, with an occasional polynuclear leucocyte present. Fibroblastic proliferation was well established at the periphery with an occasional projection between the outer layer of cotton fibers. *Black and Mercerized Cotton:* The microscopic picture was indistinguishable from that surrounding the fine cotton. *Linen:* The cellular reaction was about the same as in the forty-eight-hour specimen, with the exception that round cells could be seen occasionally. Collagen fibrils were visible, but no fibroblastic proliferation. There was a considerable amount of serum present.

Fifth Day Examination (Fig. 7).—*Plain Catgut:* There were still areas in which an intact suture could be seen, but, for the most part, the suture was broken up and in the interstices were round cells and polynuclear leucocytes with numerous collagen fibrils present. At the periphery was beginning fibroblastic proliferation with polynuclear leucocytic and round-cell reaction extending well beyond the area of fibrous tissue development. There was a moderate amount of serum present. Bacteria could not be seen. *Chromic Catgut:* The suture was intact in all sections, surrounded by serum and a fairly wide band of polynuclear leucocytic and round-cell infiltration. Collagen fibrils were numerous and fibroblastic proliferation was well established. Occasional polynuclear leucocytes were seen in the vessels. Bacteria were not visible. *Fine Silk:* Many round and plasma cells were still present. There was marked fibroblastic proliferation which not only formed a capsule but had completely isolated each fiber of silk by growing about it. *Coarse Silk:* There was slightly more cellular reaction than that about the fine silk, an occasional polynuclear leucocyte being noted among the scattered plasma and round cells. There was marked fibroblastic proliferation at the periphery and in the interstices of the suture. *Fine Cotton:* The cellular reaction was almost replaced by fibrous tissue, forming a narrow capsule about the suture. There were occasional areas in which this fibrous tissue had penetrated between a few of the cotton fibers at the periphery of the suture. *Coarse Cotton, Mercerized Cotton, and Black Cotton:* There was no appreciable difference from that produced by fine cotton, except that a few plasma and

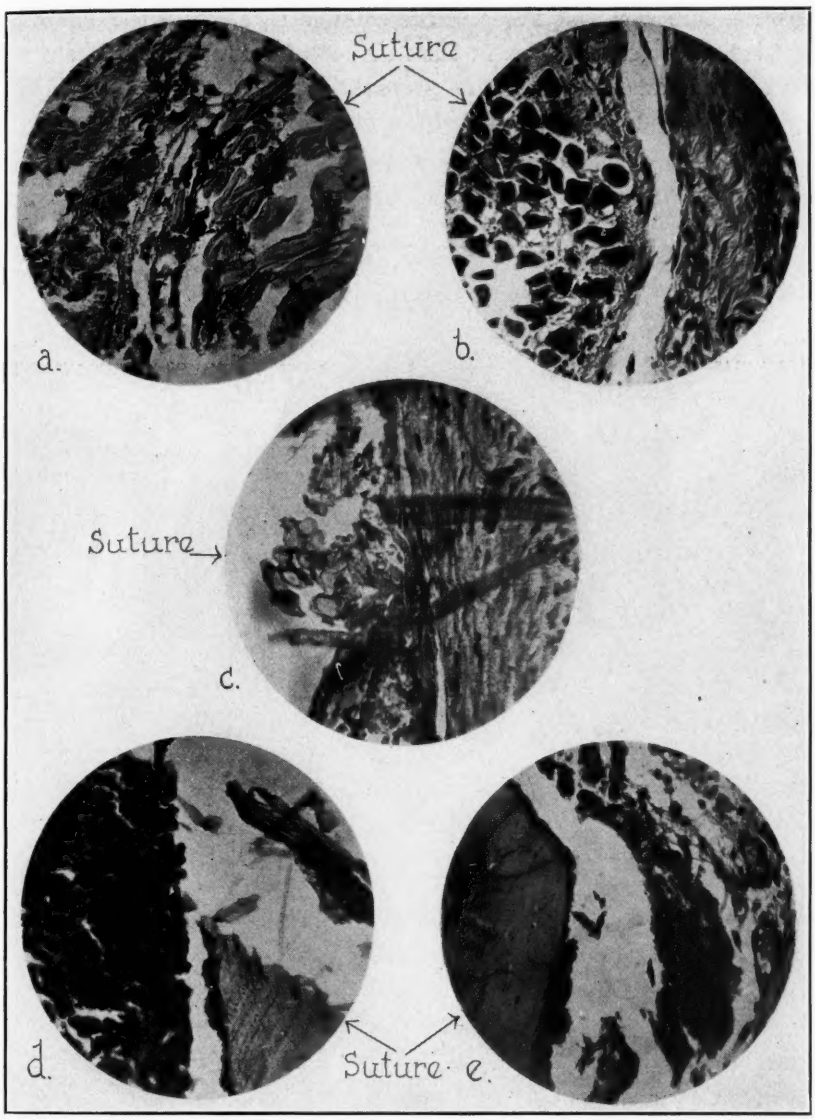

Fig. 7.—Photomicrographs of sutures implanted in tissue (rabbit) for five days. *a*, Coarse cotton (No. 30); an occasional polynuclear leucocyte is seen in the tissue and an occasional round cell in the suture. Growth of tissue into the suture is conspicuously absent. *b*, Coarse silk (No. 6 twist); there is round cell, plasma cell, and polynuclear leucocytic infiltration in the tissue, fibroblastic proliferation with capsule formation. Collagen fibrils and fibroblasts isolate the silk fibrils. *c*, Fine linen; polynuclear infiltration is decreased as compared to the forty-eight-hour specimen. Fibroblastic proliferation with beginning encapsulation of the suture can be seen. There is some penetration of the suture with fibroblasts. *d*, Plain catgut (Nos. 3 to 0); suture is fragmented and there is marked polynuclear infiltration in the surrounding tissue. Fibroblastic proliferation at the periphery is scant. Considerable serum in surrounding tissue. *e*, Chromic catgut (Nos. 4 to 0); the suture is slightly fragmented. There is polynuclear leucocytic and round-cell infiltration of the surrounding tissue with considerable serum present. There is beginning fibroblastic proliferation.

round cells could be seen in the fibrous tissue about the coarse cotton. *Linen:* There was a decrease in the cellular reaction in the surrounding tissue with an increase in the number of round cells. There was still a small amount of serum present, numerous fibroblasts, and a beginning circumferential deposition of fibrous tissue.

Eighth Day Examination (Fig. 8).—*Plain Catgut:* There was a circumferential layer of fibrous tissue around the suture which was con-

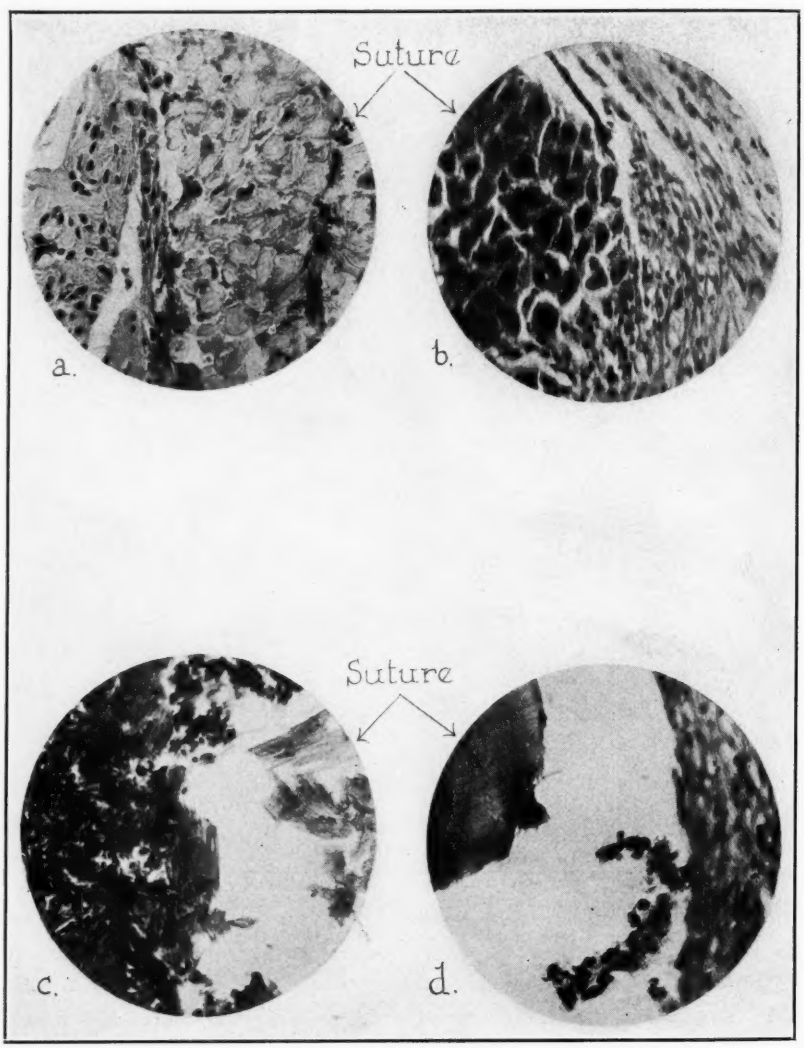

Fig. 8.—Photomicrographs of sutures implanted in tissue (rabbit) for eight days. *a*, Coarse cotton (No. 30); a few round cells are seen in the tissue and in the suture. A narrow fibrous capsule without any growth into the suture is well demonstrated. *b*, Coarse silk (No. 6 twist); round cells are present in the tissue and between the silk fibrils. Fibrous tissue throughout the suture is continuous with the fibrous capsule. *c*, Plain catgut (Nos. 3 to 0); there is marked fragmentation of the suture and mixed-cell infiltration is still rather marked in the newly formed fibrous tissue. *d*, Chromic catgut (Nos. 4 to 0); mixed polynuclear and round-cell infiltration in the newly formed fibrous tissue and the suture shows only slight fragmentation.

siderably broken up. In this fibrous tissue and directly at the periphery of the suture were approximately an equal number of round and polynuclear leucocytic cells. There was a moderate amount of serum present. *Chromic Catgut:* There was a circumferential layer of fibrous tissue about the suture with a moderate cellular reaction predominantly polynuclear leucocytic, extending well outside of the recently laid down fibrous tissue. There was a moderate amount of serum and no bacteria were seen. *Fine Silk:* The entire strand was surrounded by a capsule of fibrous tissue with the fibers of the strand separated by fibroblasts and mature fibrous tissue. There were a few round cells scattered throughout. No serum could be seen. *Coarse Silk:* There was no noticeable difference from that around the fine suture except that the round-cell infiltration was slightly greater. The fibrous capsule was about twice as thick as that seen about coarse cotton. *Fine Cotton:* A circumferential capsule of fibrous tissue, two or four cells thick, surrounded the suture. There was an occasional area in which fibrous tissue had penetrated the suture. *Coarse, Mercerized, and Black Cotton:* There was no noticeable difference from that of fine cotton. *Linen:* Whereas there was considerable cellular reaction still present in the form of both polynuclear leucocytes and round cells, there was a large amount of fibrous tissue present. A small amount of serum could be seen in and about the suture. No bacteria could be seen.

Thirteenth Day Examination (Fig. 9).—*Plain Catgut:* The broken-up catgut still had an elliptical form, but it had lost its homogeneous appearance. It was surrounded by fibrous tissue which contained round and plasma cells. There was very little tendency for the fibrous tissue to infiltrate the interstices of the disintegrated gut. There was still some serum present. No bacteria were seen. The area of fibrous tissue reaction was considerably greater than with either silk or cotton. *Chromic Catgut:* There were longitudinal, parallel cracks in the suture. At the periphery of the suture was a fibrous tissue reaction two or three times as great as that with silk and four times as great as that with cotton. A few polynuclear leucocytes and round cells were still present. There was some tendency for the fibrous tissue to penetrate the suture at its periphery. *Fine Silk:* The suture was surrounded by a thin circumferential capsule of fibrous tissue (slightly wider than that about the cotton) and the silk fibers were widely separated by invading fibrous tissue. However, there were some areas in which serum was still present with an occasional round cell in the interstices of the silk suture. *Coarse Silk:* There was little difference in the microscopic appearance as compared with that produced by fine silk, except that a few more round and plasma cells were present, and the circumferential capsule was thicker in the fine silk. *Fine Cotton:* There was a very thin circumferential capsule of fibrous tissue about the cotton suture. This fibrous tissue extended into the cotton in an

occasional area but not deeper than one fibril of cotton. There was slight shrinkage in the size of the cotton compared to the fifth day specimens. This might have been due to some variation in the tech-

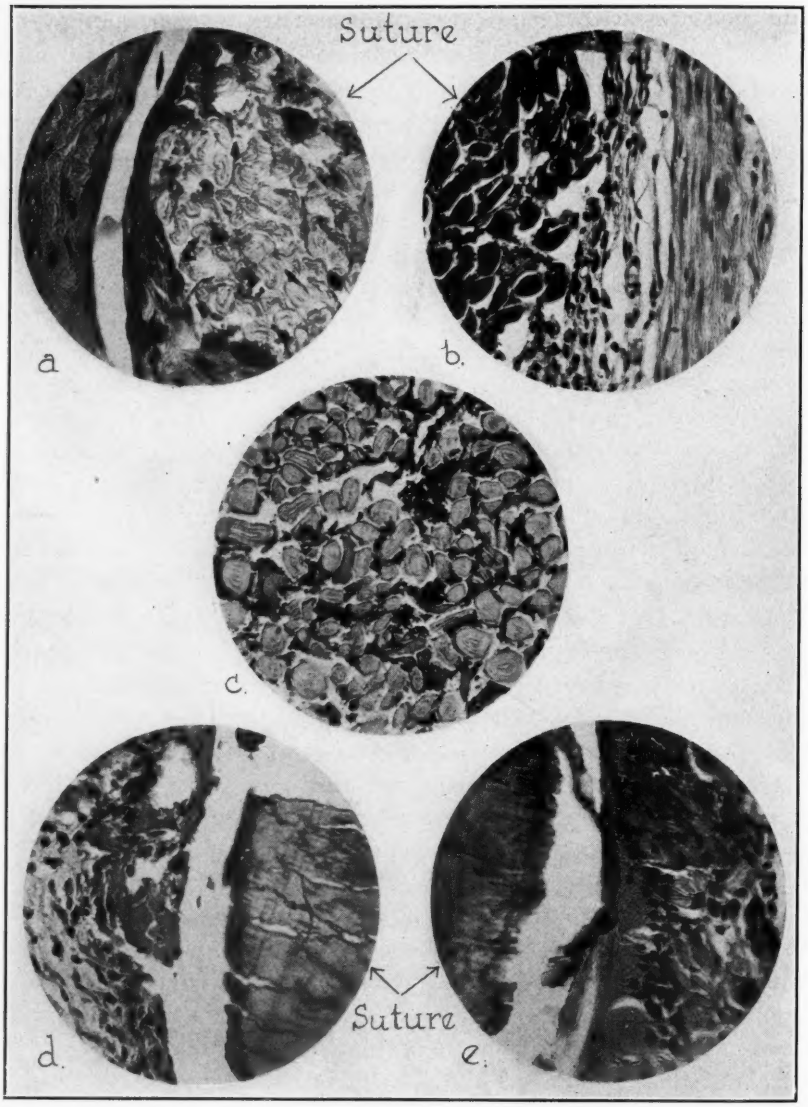

Fig. 9.—Photomicrographs of sutures implanted in tissue (rabbit) for thirteen days. *a*, Coarse cotton (No. 30); a circumferential fibrous capsule is present without growth of tissue into suture. No wandering cells present. *b*, Coarse silk (No. 6 twist); the circumferential fibrous capsule is continuous with fibrous tissue in the suture, which has isolated each silk fibril. There are a few round cells in the interstices of the suture. This microscopic picture could not be distinguished from that of serum-proofed silk. *c*, Fine linen; there are numerous round cells in the interstices of the suture with a few strands of fibrous tissue unevenly distributed throughout. *d*, Plain catgut (Nos. 3 to 0); the fragmented suture is surrounded by fibrous tissue which still contains a little serum, round and plasma cells. The fibrous tissue is gradually replacing the suture. *e*, Chromic catgut (Nos. 4 to 0); the suture is fragmented only at its periphery and is surrounded by fibrous tissue in which are some round and polynuclear leucocytes and some serum. Healing is not complete until all of the catgut is digested and absorbed.

nique in preparing the tissues. *Coarse Cotton:* The only noticeable difference in the microscopic appearance, as compared with that produced by the fine cotton, was that the fibrous capsule was slightly thicker in the former. *Black and Mercerized Cotton:* The microscopic appearance was the same as that produced by plain cotton. *Linen:* There was still a considerable amount of cellular reaction with fibrosis being more advanced than at ten days. There was no evidence of bacteria.

A gastrojejunal anastomosis in a dog performed with fine cotton, No. 50, at the end of ten days showed, on gross examination, that on the peritoneal side the junction was completely covered by serosa and no suture material could be seen. The mucosal surface was smooth, pink, and without any areas of congestion, hemorrhage, or ulceration. The cotton suture could not be seen. Microscopic examination showed that the hemostatic suture was surrounded by a marked fibroblastic reaction seven to ten cells in width. This tissue had a moderate round-cell infiltration and an occasional polynuclear cell. There was no evidence of the cotton being invaded by the fibroblasts. When the suture penetrated the muscular coat, there was less fibroblastic and wandering cell reaction with an occasional strand of fibrous tissue in the suture. Here also the fibrous capsule was extremely thin and was laid down circumferentially. Near one area of the mucosal suture was a focal abscess. This did not change the size or appearance of the cotton and the fibers were not penetrated by polynuclears and apparently the suture had no direct relation to the abscess. Where the suture was cut longitudinally, it could be readily seen that, whereas there was a thin capsule of fibrous tissue, the main body of the suture did not contain any. The suture on the serosal side had a capsule of fibrous tissue similar to that in the muscle and here also the cellular reaction was much less than when the suture pierced the mucosa and submucosa.

Serum-proofed, braided silk could not be distinguished from twisted plain silk either from its appearance or from the surrounding cellular reaction. There was questionable swelling of the plain silk fibril as compared with the serum-proofed silk, but the fibrous tissue ingrowth was as great in one as in the other.

BACTERIOLOGY

The organisms which are found in catgut have previously been referred to and a comprehensive study of the bacteriology of catgut has been made by Bulloch and co-workers, Meleney and Chatfield, and Clock.[6, 10-12] These investigators not infrequently found pathogenic anaerobes in the substance of sterilized catgut.

In the present investigation the ordinary pyogens were destroyed (in silk, thirty samples; in linen, thirty samples; and in cotton, forty-four samples) by heating beef-broth culture of the suture material to

60° C. for one hour on two successive days. The broth was then incubated for twenty-four hours and subcultures made. The original cultures were then made anaerobic by overlaying the media with three-quarters inch of vaseline. These were then incubated for fifteen days. No growth was obtained from the subcultures and no anaerobic growth in the broth containing silk. However, in five specimens of linen and four specimens of cotton there was found a motile, gram-positive, chain-forming, nongas-producing, strictly anaerobic organism which was found to be proteolytic and which we believe to be either *Bacillus histolyticus* or a similar organism.

Following boiling of linen and cotton for ten minutes, the above type of anaerobe was found to be present in 7 per cent; whereas, all those boiled for twenty minutes were sterile. When samples from the same series were autoclaved for fifteen minutes at fifteen pounds pressure, growth occurred in three of forty-four (6.8 per cent) specimens of cotton and linen. This growth may be due to a factor which has previously been referred to by Goris.[35] Goris showed that, when stoppers made of cotton were placed in tubes containing suture material, these prevented thorough sterilization, both when a temperature of 120° C. for one hour was used and when 130° C. for thirty minutes was used. However, with the tubes open, using the same lengths of time and temperatures, all suture material became sterile. As we used plugs in our tubes, these probably were responsible for the presence of organisms following autoclaving. On repeating the autoclaving of linen and cotton suture material in open-mouthed tubes, sterility was established in 100 per cent.

Whereas anaerobic organisms were demonstrated in both linen and cotton, they were not pathogens, but we believe that it is possible for both tetanus and gas bacilli to be present in these two materials and further investigation is being carried out with this in mind. Silk, apparently, does not contain anaerobic organisms but only the ordinary pathogenic aerobes. This last material will also have further study from the standpoint of its bacteriology.

COMMENT

Absorbable sutures produce essentially a wet reaction in tissues, which is an attempt on the part of the host to digest the suture by means of proteolytic ferments derived from leucocytes. This wet reaction consists of excessive fluid and cellular exudation which is associated with a concomitant delay in the appearance of fibroblasts. Both of these factors deter wound healing. On the other hand, it has been demonstrated that nonabsorbable suture produces a minimum amount of exudation (dry reaction) and that fibroblastic proliferation begins early. The results of our investigations corroborate the observations of Howes and Harvey[14] as regards the tissue reaction to catgut and

silk. At the end of thirteen days there was complete healing and no evidence of inflammatory reaction when the wound was closed with silk; whereas, wounds closed with catgut showed inflammatory reaction as long as the catgut was present, which was generally from nineteen to twenty-three days (chromic catgut). Equally important was the fact that catgut interfered with wound healing because of the later appearance of fibroblasts (catgut five days, silk three days). When the wounds were closed with cotton, the tissue reaction was least, in that there was less inflammatory reaction and the appearance of the fibroblasts was earlier (fibroblastic proliferation was evident twenty-four hours earlier in wounds closed with cotton than with silk). Whereas all inflammatory reaction had entirely subsided in thirteen days in silk-closed wounds, inflammatory reaction occurred as early as ten days in those closed with cotton.

As previously mentioned, it is generally assumed that nonabsorbable sutures produce minimal tissue reaction and therefore are preferable to absorbable ones. This assumption is substantiated by our investigation with silk and cotton. On the other hand, linen, which has been used surgically for a much longer period of time, produces a much greater reaction than silk and cotton, and up until the fifth day has almost as great reaction as catgut. From the fifth to the tenth days the cellular reaction to linen slowly diminishes until at the end of that time (ten days) the reaction is only slightly more than that of silk and cotton (Fig. 10).

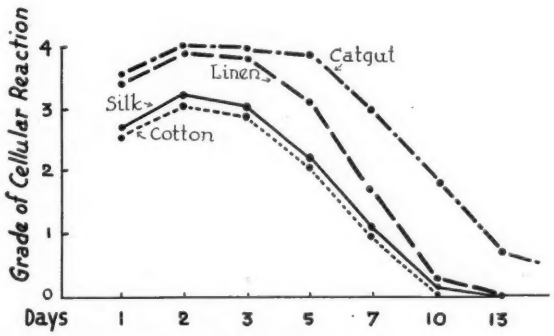

Fig. 10.—Graph illustrating the differential in cellular reaction of various suture materials.

Microscopically there were obvious differences in and about silk and cotton sutures used to close the wounds. In the former (twisted and braided), there is wide separation of suture fibrils, first by serum and wandering cells and later by fibroblasts. In the latter, because of the natural twist of the cotton fibrils, maintaining a compact suture even after insertion in the wound, there is minimal separation of the fibrils and practically no tissue ingrowth. These differences are of little significance in clean wounds but may be of great importance in the presence of infection as granulation tissue invading the interstices of the

silk may prolong the infection and may be responsible for the occasional draining sinus in wounds closed with silk. Although this will account for the occasional persistent sinus in silk-closed wounds, contrary to the general opinion contaminated wounds closed with silk are much less likely to become infected than those closed with catgut and usually heal by primary intention.

As Halsted[4] originally stated and as more recently emphasized by Howes, it is unnecessary to use a suture material stronger than the tissues coaptated. Generally, fine sutures should be used because not only is a heavy suture frequently unnecessary, but it is actually harmful because it permits by virtue of its increased strength greater tension, mass ligation, and strangulation.

As originally emphasized by Halsted,[4] silk should be used as interrupted sutures. Our experience substantiates this contention. Early in our use of nonabsorbable material continuous sutures were used in the fascia and peritoneum, which resulted in two cases of persistent, progressive inflammatory reaction associated with marked fibrous tissue proliferation (Schloffer's tumor). Both of these resisted therapy until the tumors, which extended down to and included the peritoneum, were excised. Closure of these wounds with interrupted silk resulted in prompt healing. Because of the fibrous tissue capsule surrounding the silk suture and because of the possibility of infection extending along the course of the silk suture resulting in persistent and multiple sinuses, the use of continuous silk sutures is to be condemned. Although cotton produces less reaction than silk, it is still nonabsorbable and therefore only interrupted sutures should be used and these should be of as small diameter as possible. Whereas Howes has recently advocated the use of catgut in this same way, we believe that the excessive number of relatively large knots and the necessity of cutting the suture long to prevent the knot from untying will produce enough increased inflammatory reaction in the wound to offset any possible advantage gained.

Halsted advocated that silk sutures be cut "on the knot" because there is little likelihood of the knot's becoming untied in contradistinction to catgut, and because of the undesirability of leaving a long piece of silk in the wound. As Taylor[20, 21] has recently demonstrated, serum-proofed braided silk sutures, when cut immediately "on the knot," are likely to become loosened under tension when a square knot is used; but, when a triple throw knot is used, it may be cut on the knot. Our experience with cotton shows that the suture can be cut closer to the knot than when using silk. This is due to the fact that cotton, not being serum-proofed, has a higher frictional coefficient as Taylor showed to be true in silk which had not been serum-proofed.

As mentioned above, the tensile strength of a suture is decreased by the presence of a knot (Fig. 3). Actually the coaptation of wound

surfaces by suture results in an increase in the tensile strength of the suture by one-third when the knot has been made. After completion of the knot, the wound edges are held by a double strand, one in which the knot is located and the other intact strand. By tensile strength determination, we have demonstrated that such a suture is 35 per cent stronger than a straight unknotted strand.

Whereas wound healing occurs best in the absence of infection and when nonabsorbable sutures are used, many fear the use of nonabsorbable sutures in the presence of contamination because of the foreign body which is believed to predispose to sinus formation. Although occasionally in the presence of infection a sinus occurs which will persist until the silk suture is extruded or removed, infection of contaminated wounds closed with silk is much less likely to occur than in similar wounds closed with catgut. Although our experience with cotton is not yet as extensive as that with silk and catgut, we are of the definite opinion that sinus formation is even less likely than with silk. We have seen severely infected wounds in which cotton has been used throughout, heal without sinus formation and without extrusion of the cotton. Whereas the use of silk sutures in strictly clean cases results in very early healing and little reaction as shown by the experience of those who have used it, we believe, contrary to the opinion of most of its advocates, that the most important use of nonabsorbable sutures is in the grossly contaminated wounds. This contention, at variance with those of others, is based upon the experience that the grossly contaminated abdominal wound closed with catgut is particularly likely to disrupt, probably because of two factors: (1) delay in wound healing because of the infection, and (2) early digestion of the suture material by the large amount of proteolytic ferment liberated from the leucocytes. In such an instance the coaptating suture becomes valueless before wound healing has been completed, or, in some instances, even started. If, however, a nonabsorbable suture, particularly cotton, is used, the wound is held intact until the infection has subsided and complete healing has occurred.

Irrespective of one's belief concerning the relative values of absorbable and nonabsorbable sutures, one cannot deny that strictly clean operations, such as mammectomies, thyroidectomies, and herniorrhaphies, in which only nonabsorbable sutures are used, are followed by much less reaction, absence of serum, and earlier healing than in those in which absorbable material is used. Prior to the use of nonabsorbable sutures, we were never able to close thyroidectomy or mammectomy wounds, in both of which many ligatures are placed, without drainage because of the invariable accumulation of serum. Since the use of nonabsorbable sutures (silk and cotton), drainage has not been used in these cases and healing has occurred promptly without serum ac-

cumulation. It should be emphasized, however, that marine sponge compression dressings are used almost routinely.

From a technical standpoint, it is easy in closing laparotomy wounds to insert all the sutures in a layer before tying, as in this way the wound tension can be transmitted to all the sutures and also time is actually saved.

Up to the present, cotton has been used throughout the operation in ninety-one patients. All wounds except three have healed by primary intention; two of these were infected at the time of operation and the other was in an old scar, the previous wound having been drained at the time of operation two years before. It has been used in colostomies, repair of hernias, thyroidectomies, radical and simple mastectomies, cholecystectomies, perforated ulcers of stomach and duodenum, repair of episiotomy wound, repair of tendon, suturing of split skin graft, purse-string sutures in appendectomies, ligation of external carotid, gastrectomies, and pneumonectomies.

Cotton, size for size, is two-thirds as strong as catgut and three-fourths as strong as silk. The mercerized cotton is 15 per cent stronger than plain cotton, but, when used under tension, should always have a triple throw knot placed in it as its frictional coefficient is less than that of plain cotton. However, cotton maintains its original tensile strength longer than catgut, linen, or silk (Fig. 4).

In the use of cotton, as in all other sutures, it is desirable that as fine a suture as possible be used. It is recommended that for ligatures on small vessels of the subcutaneous fat and other areas, No. 60 plain cotton be used and that No. 30 plain cotton or "heavy duty" mercerized cotton be used for approximation of the peritoneum and fascia. Where the so-called retention sutures are to be employed, No. 20 crochet cotton can be used. For through-and-through sutures of the abdominal wall, No. 10 mercerized crochet cotton is best. For skin closure, it is better to use black cotton, because the white is somewhat difficult to find at times due to its becoming stained with blood.

CONCLUSIONS

1. Catgut has been demonstrated to be (a) a strong suture before being placed in tissue; (b) absorbed at a variable rate which depends on its size, the chemicals present, and the reaction of the individual in which it is placed; (c) a possible source of allergic reactions; (d) a deterrent in wound healing; (e) unreliable when knotted under tension unless a triple or quadruple throw knot is tied; and (f) above all, a possible cause of wound infection.

2. Nonabsorbable suture materials: (a) can always be heat sterilized; (b) produce no allergic reactions; (c) allow rapid wound healing; (d) allow reliable square knots to be tied.

3. While silk and linen show early decrease in tensile strength as compared to cotton, they also are somewhat stronger before being implanted in tissue.

4. Cotton and linen, as products of the field, may contain spore-forming anaerobic pathogens, but the average threads obtained on the market have not contained any pathogenic organisms. Silk contains the ordinary pyogens, but anaerobic organisms were not found.

5. Chemically treated silk and catgut are proteins, but the former is nonabsorbable and excites much less tissue reaction.

6. Silk wounds in the presence of an infection (not contamination) may develop sinuses which will not heal until the suture is removed or is expelled because of the presence of infected granulation tissue in the silk itself.

7. There is little difference in the wound healing when serum-proofed and nonserum-proofed silk is used.

8. Braided silk has greater tensile strength than twisted silk.

9. Cotton shows much less tendency for tissue ingrowth and is therefore less likely to cause sinuses in the presence of infection than silk. (Three cases that were infected have healed without sinus formation.)

10. Cotton is proposed as a pliable, easily sterilized, nonirritating, inexpensive suture of sufficient strength in the recommended sizes for most surgical procedures. It has been used in ninety-one surgical procedures, primary healing taking place in eighty-eight cases.

11. Halsted's silk technique is recommended not only for silk, but also for cotton.

12. The reaction of tissue to the implanted suture was graded according to the amount and persistence of leucocytic infiltration, amount of serum and fibrin, the appearance time of fibroblasts, and length of time necessary to produce final healing. Accordingly catgut, by producing the most reaction and slowest healing, was graded 4; linen, 3; silk, 2; and cotton, producing the least reaction and earliest healing, was graded 1 (Fig. 10).

The authors appreciate the technical assistance of Miss Edith Honold and Miss Mary Elizabeth Davenport.

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PERSISTENT ABDOMINAL FECAL FISTULAS DUE TO REGIONAL ILEITIS

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CLINICAL studies on the subject of regional ileitis have been so frequent in the last few years that another article on this subject should, perhaps, be prefaced by an apology. The justification for the present communication is that it is a more intensive study of one of the particular phases of this disease than has yet appeared. Judging from the late stages in which these patients are still being seen, this particular complication of the disease seems to be the least recognized of all the manifestations of regional ileitis. The cases of regional ileitis which constitute the subject of this study are characterized by the presence of chronic intractable fecal fistulas originating, as a rule, in the terminal ileum. They developed, usually, following appendectomy or the drainage of ileocecal abscesses supposedly of appendical origin. A review of all the cases of fecal fistulas operated upon at the Mount Sinai Hospital since 1927 (Table I) shows that these constitute a large proportion of all cases of chronic fecal fistulas, that they are indubitably due to regional ileitis and not to appendicitis or tuberculosis with which they were formerly confused, and that their chronicity and intractability

TABLE I

CAUSES OF FECAL FISTULAS AT MOUNT SINAI HOSPITAL (1927-1939)*

1. Regional ileitis		14
2. Appendicitis		21
a. Primary operation at Mt. Sinai Hospital	16	
13 closed spontaneously		
3 required operative closure		
b. Primary operation elsewhere	5	
4 lip fistulas		
1 multiple perforation of small intestine		
3. Actinomycosis		4
4. Perforated carcinoma		2
5. Regional colitis		1
6. Tuberculous salpingitis		3
7. Tuberculous peritonitis		1
8. Tuberculous appendicitis		1
9. Tuberculosis of intestines		1
10. Tuberculous colitis		1
11. Diseased adnexae and abscess		2
12. Uterine and adnexal operation		8
13. Perforated sigmoid diverticula		2
14. Sliding hernia of sigmoid		1

*Fistulas subsequent to operative procedures upon the bowel are not included.

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are due to a large extent to the failure to appreciate that they are complications of an underlying intestinal disease.

Regional ileitis either begins as, or rapidly becomes, an ulcerative disease. The type of clinical course which will dominate the picture of the disease is determined to a large extent by the future course of these ulcers. They may remain relatively superficial and the inflammatory and proliferative reactions which they incite may remain chiefly intramural. In such instances the symptoms which develop are the result of changes limited to the bowel wall and are either enteric or obstructive in character. In other cases penetration or slow perforation of these ulcers tends to occur. The serosal layers of the bowel become involved and a picture of peritoneal inflammation is produced. Actual perforation either into previously sealed-off portions of the abdominal cavity or between the leaves of the mesentery produces signs of localized intraperitoneal suppuration and abscess formation. The introduction of drainage material into such an abscess, already communicating with diseased bowel, almost inevitably produces a fecal fistula. It must be emphasized that there is not necessarily any parallelism between the intramural and perforating aspects of the disease, nor is perforation necessarily a late stage. In this respect the course may be compared to that of peptic ulcer where perforation may be the earliest symptom, may occur at any stage, or may never occur at all.

Inasmuch as the terminal ileum is the portion of bowel usually involved in this ulcerative process, it is evident that for topographical reasons the local signs and symptoms produced closely resemble those of acute appendicitis. As appendicitis is by far the most common cause of acute infection in the right lower quadrant, it is natural that such sequelae of suppuration as fistulas should be primarily considered a complication of disease of the appendix. The number of such chronic cases which we have encountered has persisted as such largely because of this point of view. It might be of interest to record the reasons for our own change of viewpoint with respect to the problems of such chronic intestinal fistulas.

1. It is unnecessary to postulate an acute appendicitis either for the production of regional ileitis in general or the type with fistula formation in particular.

In our original series of regional ileitis[1] it was noted that, in those cases where a prior appendectomy had not been performed, typical intestinal lesions were found with normal appendices. In addition, three further cases of abscess and persistent fecal fistulas which had previously been subjected to multiple operations may be cited. The fistulas had been definitely attributed to appendicitis by various operators, but eventual resection revealed normal appendices still in situ with fistulas originating in diseased terminal ileum. Further evidence

along these lines is furnished in the case of two patients dying prior to operation, upon whom post-mortem examinations were performed. In these, two large right lower quadrant abscesses were found arising from perforations in the terminal ileum which were the seat of a typical ulcerative cicatrizing enteritis. The appendices in both these cases were normal.

2. Regional ileitis has a marked tendency toward perforation.

This is evidenced by the high incidence of spontaneous enterocolic fistulas, intramesenteric abscesses, and sealed-off intra-abdominal abscesses accidentally encountered at operation for the enteric or obstructive type of the disease.

3. The pathologic changes in segments of bowel, the seat of fistulas due to regional ileitis, and those where the fistulas are definitely due to appendicitis are quite different.

In cases where the intestinal fistulas have developed as a result of extrinsic factors, such as peri-intestinal suppuration, inflamed bowel wall, pressure of drainage material following operation for appendicitis, the changes in the involved portion of bowel are limited rather sharply to the region of the internal opening or openings. Although the adjacent serosa may show evidence of chronic inflammation, the mucosa and submucosa show no evidence of any ulceration or hypertrophy. In regional ileitis, however, where the perforation is due to intrinsic disease of the bowel wall, pathologic alterations are not limited to the region of the perforation, but involve an entire segment. These pathologic changes may be as marked at an area some distance from the perforation as at the point itself. It may further be noted that a common occurrence in fistulas due to regional ileitis is the finding of tracts running between the leaves of the mesentery having the internal opening at the mesenteric border (Fig. 3). This is easily explained by the fact that in regional ileitis ulcerations on the mesenteric border of the bowel are frequent. It would be difficult to explain how appendicitis could cause a fistula originating in this particular section of the bowel.

4. Persistent fecal fistulas following acute appendicitis are relatively uncommon.

From the evidence gathered in this institution it would appear that in spite of the great frequency of acute appendicitis chronic fecal fistulas are an uncommon complication. Attention was directed to this feature from another standpoint by Colp.[2] In a study of 2,840 cases of acute appendicitis on the wards of the Mount Sinai Hospital, he found only 33 instances of postoperative fecal fistulas, or 1.1 per cent. Of these, only 3 required operation. During the past ten years, approximately 2,900 cases of acute appendicitis were operated upon on the ward service of this institution (fatal cases are not included). Postoperative fecal fistulas developed in 16 of these, only 3 of which failed to close spontaneously.

5. The clinical behavior of fistulas due to acute appendicitis and of those due to regional ileitis are different.

The clinical characteristics of fecal fistulas definitely due to acute appendicitis are the following. They seem to follow the severer types of the disease. They appear within the first few weeks postoperatively and usually close spontaneously. When spontaneous closure occurs, it is apparently permanent. When the fistula persists, some obvious cause can usually be found, such as lip fistulas, prolapse of cecum, or distal obstruction. Thus, of the 16 cases of fecal fistulas following acute appendicitis in the second series mentioned above, 13 closed spontaneously. Of these, 9 healed within a month of their first appearance. The remaining 4 closed within periods of two to six months. Once they had closed there was no further recurrence. Only 3 of the 16 cases of fecal fistulas required operative closure. Two of these were lip fistulas, one of the ileum and the other of a perforated angulated appendix which prolapsed into the wound following drainage of an appendix abscess. In the third case an abscess had dissected subserosally along the cecum so that normal healing of the appendix stump was probably interfered with.

There was another group of 5 cases in which the primary appendectomy for proved acute appendicitis had been performed elsewhere and who applied at this institution for treatment of their fecal fistulas. In 4 out of 5 the persistence was definitely due to lip fistulas. The fifth case is of considerable importance and interest. It is the only case in this series in which continued suppuration and fecal discharge following operation for bona fida acute appendicitis was maintained by communications with ulcerations in the small intestine without any mechanical or obstructive factor to account for such persistence. This patient had originally been operated upon for perforated appendicitis with abscess lying mesially and completely surrounded by coils of small bowel. For months she continued to show evidences of extending intra-abdominal suppuration and fecal fistulas, finally dying from progression of the infection in spite of attempts to furnish adequate drainage. As a matter of fact, it was thought that the patient was probably suffering from regional ileitis. Autopsy revealed abscess cavities between loops of terminal ileum. In one of these loops there were a number of small perforations which communicated with the abscesses. Aside from these ulcerations, which were localized over an area about one inch in diameter, there were no changes either in the mucosa or in the submucosa. The picture was definitely not one of regional ileitis. As stated before, this is the only case in the series in which suppuration and fecal fistulas from appendicitis simulated regional ileitis.

As will be seen, fistulas due to regional ileitis usually behave in a manner different from those due to acute appendicitis. They do not al-

ways develop in the immediate postoperative phase. They may appear following the drainage of a residual abscess, which in turn may have developed months or even years following the initial operative procedure. Although temporary spontaneous closure may occur, recurrences are almost certain. Definite mechanical factors interfering with closure are usually absent.

CLINICAL FEATURES AND PATHOLOGY

The symptoms of the underlying ileitis which lead to the initial laparotomy may be either acute and predominantly peritoneal or chronic and mainly enteric. In the chronic cases changes in the ileum may or may not be noted, depending on the experience of the operator, the thoroughness of exploration, and the degree of involvement. Formerly, the appendix as a rule was removed, and, when noted, the condition in

Fig. 1.—Appearance of the abdominal wall of a patient who had been subjected to multiple unsuccessful local operations for fecal fistulas due to regional ileitis. There was a severe dermatitis due to the irritating intestinal and purulent discharge.

the terminal ileum was usually regarded as tuberculosis. External fecal fistulas develop only in a small proportion of such cases, and then, as a rule, not immediately after operation. In a certain number, however, progression of the disease with penetration and perforation of formerly superficial ulcers at some subsequent period will give rise to intra-abdominal abscesses. Four of the 14 cases in this series ran such a course. Intra-abdominal abscesses developed at periods of four, twelve, and eighteen months, and in 1 case seven years after the initial laparotomy. Development of fecal fistulas followed immediately upon the incision and drainage of these collections.

When the original laparotomy is undertaken for acute peritoneal symptoms, differentiation from appendicitis presents great difficulty clinically and at times at operation. Acute peritoneal symptoms in regional ileitis may occur during two different phases of the disease, the underlying pathology being different in each. In one of these there is a diffuse acute inflammatory process, limited to the terminal ileum, without actual suppuration. This is usually easily recognized operatively by the thickened, edematous, blotchy ileum. In this particular phase we know from experience that resolution will occur in a consider-

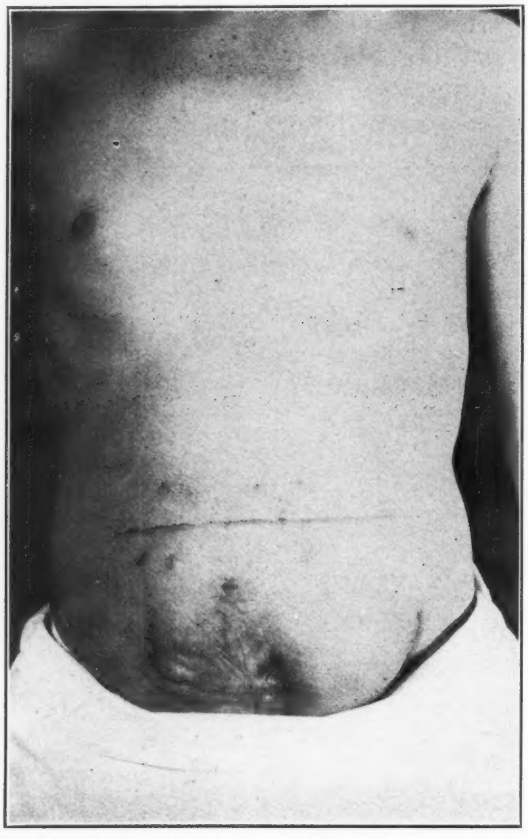

Fig. 2.—Appearance of abdominal wall following an iliotransverse colostomy with exclusion. The condition of the skin of the lower abdomen necessitated the employment of a transverse incision above the umbilicus. At present there is only an occasional watery mucoid discharge.

able number of cases. In this group development of fistulas in the immediate postoperative phase is also uncommon. Three of the 14 cases in this series were previously operated upon, as far as can be deduced from the study of the primary operative findings, during this acute stage of ileitis. One patient developed an intra-abdominal abscess followed by fecal fistulas seven weeks later. Another developed an abscess eight months postoperatively which healed for a space of two years, only to be followed by recurrence of the abscess with subsequent fistula at that

time. In the third patient an abscess and fecal fistula developed eight years following the original laparotomy.

In the other phase of regional ileitis, where peritoneal symptoms develop, the underlying cause is perforation of an ulcer in a more or less chronically diseased bowel with the production of an abscess. Seven, or one-half of the cases in this series, were subjected to primary operation at this stage of the disease. Peculiarly enough, the intestinal complaints in this group, while they could be elicited by careful questioning, were not very prominent in the patient's mind. The peritoneal symptoms which finally led the patient to seek aid were also not very severe, and

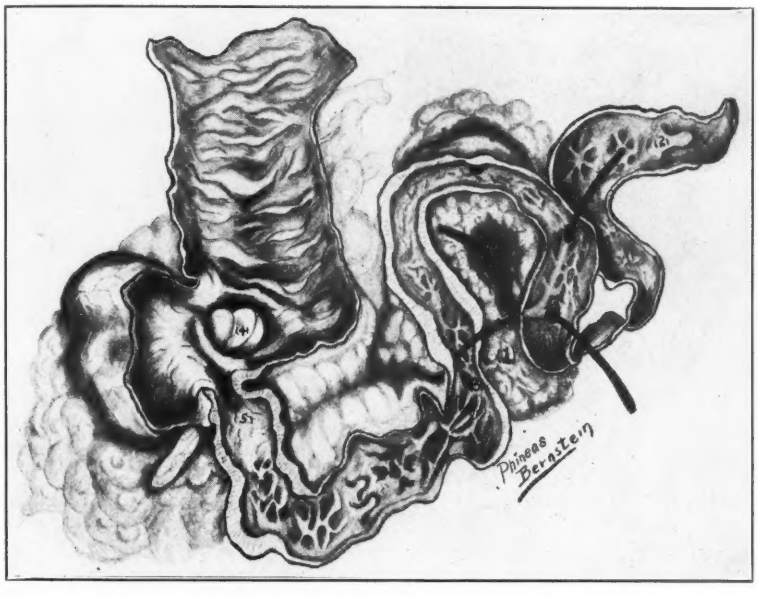

Fig. 3.—Drawing of a specimen secured at autopsy in a case dying of regional ileitis with abscess formation and peritonitis (from Arnheim[6]). The probes lead from ulcerations on the mesenteric border of the bowel into an abscess between the leaves of the mesentery. This abscess in turn communicated with an intraperitoneal abscess. The pathogenesis of fecal fistulas due to regional ileitis is clearly shown in this drawing. The communications with the bowel and the peri-intestinal abscesses are already present. It needed only the insertion of a drain to produce an external fecal fistula.

usually were of two to four weeks' duration. It was not uncommon for the patient to remain ambulatory for a number of weeks with these relatively mild symptoms and then to require hospitalization for sudden exacerbation of the symptoms. In all of these cases fecal fistulas developed immediately after operation. Summarizing the above experiences, it may be said that fecal fistulas due to regional ileitis do not always develop immediately after operation. They may appear following drainage of a residual abscess, which in turn may develop months or years after the primary operation. Drainage of abscesses in these cases almost invariably leads to persistent fistula formation. In 2 cases, however, temporary healing of abscesses occurred; once for four months, and once for two years.

Typical fistulas which develop in regional ileitis are indirect, tortuous, often multiple. Their internal openings are small and are frequently situated on the mesenteric side of the bowel, due to the frequency of ulceration at that portion of bowel. Perforation of such ulcers results in inflammatory processes between the leaves of the mesentery (Fig. 3). This is an important and distinctive feature of regional ileitis. Its importance may be gauged by the fact that in 10 of these 14 cases there was definite evidence of an extension along this route. In 4 of these instances fistulous tracts were found to enter the bowel on its mesenteric

Fig. 4.—Radiograph of an ileosigmoidal fistula complicating an external fecal fistula in regional ileitis. Following the introduction of barium into the rectum, there was a rapid flow into small intestinal loops.

side. In 4 other cases localized intramesenteric abscesses were noted at some time during the course of the disease. In 2 cases widespread extension in the cellular tissue of the mesentery extended retroperitoneally to produce extensive and fatal retroperitoneal phlegmons. The coincidence of intramesenteric or diffuse or localized retroperitoneal suppuration in connection with external fecal fistulas should always serve to call the attention of the operator to the possibility of regional enteritis as an underlying cause.

Complicating ileocolic fistulas occurred 4 times, once with the transverse colon, and on 3 occasions with the sigmoid (Fig. 4). They resulted from the adhesion of one of these movable segments of colon either to diseased bowel or to an area of mesenteric suppuration. In the former instances there was a direct communication, almost like a stoma. In the cases where the mesentery of the small bowel was adherent to the sigmoid, the nature of the type of adhesion was frequently not clear in the beginning. The presence of dense adhesions, with induration between colon and terminal ileum or its mesentery, should always be suspected as evidence of fistulous communication and appropriate precautions taken when they are separated. Secondary communications with the cecum occurred six times in this series. In a number of instances communication was along the mesenteric side of the cecum apparently due to burrowing of pus between the leaves of the mesentery of the terminal ileum. Another type of fistula seemed to be due to secondary involvement of the cecum from repeated operative manipulations, chronic pericecal suppuration, and prolonged drainage. Akin to this group were those cases where coincident appendectomy accompanied the drainage of an abscess due to ileitis. Here, again, the chronic regional suppuration probably acted to prevent proper healing of the appendix stump with secondary dehiscence and fistula formation. The ileal fistulas in all instances but one originated in the terminal two feet of ileum. The bowel in all instances in which it was examined or resected except one was found to be greatly thickened, hard, hoselike in character. The changes in the mesentery have been referred to. The internal aspect of the bowel and the microscopic picture were typical of an ulcerating hypertrophic enteritis. The discharge from the fistulas was usually purulent and contained granules. The absence of grossly fecal discharge would be expected from the small size of the inner openings and the length and tortuosity of the tract. Eversion of mucosa at the internal opening is ordinarily absent. Where exploration with fruitless attempt at local repair had been made, resultant necrosis of part of the sutured bowel wall at times produced a discharge more copious and intestinal in character. Most of these patients ran a febrile course which was usually low grade. Bouts of high temperature were not uncommon, probably as a result of temporary blockage of fistulous tracts. Recurrent attacks of abdominal colic, vomiting, diarrhea, or obstipation frequently gave evidence that the underlying enteritis was still active. As a result of this combination of intraabdominal suppuration and persistent enteritis, most of these patientss had lost considerable weight and strength, were anemic and in poor general condition. In a few, however, nutrition was fairly well maintained.

In the preoperative investigation, the following studies were performed:

1. *Administration of Insoluble Carmine by Mouth.*—In cases where the discharge from the fistulas was mainly purulent this test was often decisive in establishing the presence of intestinal communications. It was positive in 12 of 14 cases.

2. *Injection of Lipiodol Through the Sinus.*—This was performed in 12 instances. In 5, communications with the ileum were easily demonstrated. In 3, no radiologic evidence of communication with the bowel could be obtained. (The carmine test was, however, positive in these 3.) In 3 instances, only communication with the cecum could be visualized, although at operation ileal openings were also encountered. These findings deserve comment. It is obvious that failure to define a communication with the ileum is no proof that such a communication is absent. Because of the narrowness and tortuosity of these tracts, it is very likely that insufficient pressure is obtained by injection to force the contrast medium into the bowel. This is especially apt to be the case if the tract enters the bowel via a peri-intestinal abscess cavity. In our experience concomitant cecal fistulas frequently have larger internal openings than the ileal fistulas, and thus permit the entrance of the injected lipiodol, which continues to pass along the line of least resistance. In a number of cases the surgeon apparently was convinced by the x-ray picture that the main lesion was in the cecum and the operation was restricted to closure of the cecal fistula.

3. *Gastrointestinal and Colonic Studies With Barium.*—These have not been of much assistance in localizing the external fistulas. In a number of cases, however, radiologic evidence of regional ileitis was obtained. Irregularities and spasm of the sigmoid may be revealed, always suggestive of fistula formation. In 1 case the presence of such an ileosigmoid fistula was actually demonstrated.

4. *Removal of Specimens From the Sinus Tracts and Walls of Abscess Cavity for Pathologic Study.*—These have usually been of negative value except in cases of actinomycosis.

Incidentally, the differentiation from abdominal actinomycosis may be extremely difficult. The question has risen 3 times in the past year. In 2 instances in which the preponderance of evidence seemed to favor the diagnosis of regional ileitis, the diagnosis of actinomycosis was finally established by biopsy. Actinomycosis was strongly suspected in the third case, but post mortem revealed regional ileitis. In regional ileitis, burrowing in the abdominal parietes is not as extensive as in actinomycosis. Retroperitoneal burrowing and extension, however, may occur in both. Large, indurated, boardlike masses, and thick dense sinus walls are not as common in regional ileitis as they are in actinomycosis. Demonstrable communication with the bowel seemed to be more common in regional ileitis. Subhepatic or subphrenic extensions have not been encountered in regional ileitis but are common in actinomycosis.

In our experience the issue can in some instances be definitely settled only by demonstration of the ray fungus.

As far as the supposedly tuberculous nature of many of these fistulas is concerned, we feel that it would be superfluous to discuss at length the reasons for the long-continued confusion of all types of nonspecific granulomas of the bowel with hypertrophic tuberculosis. This point has been very thoroughly discussed in the literature both in this country and abroad.[3-5] Suffice it to say that in none of the specimens resected in this series was there any evidence of tuberculosis.

TREATMENT AND PROGNOSIS

The primary point to be considered in the treatment of these intractable fecal fistulas is that they are but an incidental complication of a chronic ulcerative enteritis. Bearing this in mind, the futility of attempts to achieve cure by plastic closure of intestinal openings or by ileostomy becomes apparent. Not only may sutures fail to hold in the chronically thickened and inflamed bowel, but partial necrosis of the sutured portion may occur with enlargement of the internal orifices and a greater fecal discharge. The performance of an ileostomy proximally to protect such a suture line also has its disadvantages. During the period in which the ileostomy functions, the diversion probably facilitates healing of the diseased segment. A relative stenosis, however, may develop at that point, a factor which will prevent closure of the proximal ileostomy tract when the tube is later withdrawn. A new and profusely discharging fistula may develop at this point, as occurred in two of our cases.

Drainage of recurrent abscesses is of course necessary. Provision of adequate drainage will not, however, by itself insure closure of the fistula. When retroperitoneal suppuration is present, the most extensive drainage will not prevent further spread of the phlegmonous inflammation, constantly fed by intestinal extravasation. Nine of the 14 cases in this series were unsuccessfully treated by repeated drainage and local repair, 2 at this institution and 7 elsewhere. Conditions appeared only to be aggravated by these attempts, the formation of new fistulas, intestinal obstruction and adhesions, and persistent suppuration and intestinal symptoms rendering the patient more miserable and the final operation more difficult.

To achieve healing of the fistulas and to stop the further course of the disease, it is necessary to perform either enterocolostomy with exclusion, or resection of the diseased area. As a general principle, when performing a short-circuiting operation, it is the custom in this institution to practice division of the ileum proximal to the lesion. This prevents the passage into the diseased area of intestinal contents, some of which will otherwise pass by the enterocolic stoma. When this happens, the diseased segment is not put completely at rest and there is

still a tendency for intestinal contents to find their way through the fistulous opening. Furthermore, it is not uncommon for a trap to form between the diseased segment and the enterocolic stoma which, with increasing distention, may produce a new train of symptoms. For these reasons we feel that an enterocolostomy for fistulas due to regional ileitis should always be accompanied by complete exclusion. Reported failures of fistulas to heal following enterocolostomy are in a certain number of instances probably due to failure to observe this principle.

Six cases in this series were treated by ileocolostomy with exclusion. Complete healing of the fistulas and marked general improvement took place in 4 of these. In 1 case there was marked general improvement and practically complete healing of the fistula. This patient, however, continued to have recurrences of attacks of abdominal pain and fever, followed by a discharge of mucus and pus. This failure was finally demonstrated to be due to a closed loop mechanism between an area of perforation and stenosis just proximal to the ileocecal junction and the closed end of the bowel about three inches away. In the other case there was a concomitant ileosigmoidal fistula. There was marked diminution but not complete stoppage of drainage and with only slight general improvement. Fecal drainage through the excluded portion was shown to be due to retrograde passage via an excluded ileosigmoidal fistula. This patient later died following a complicated secondary resection.

Seven cases were subjected to resection (including 2 of the above ileocolostomies). There was 1 death, the one mentioned above. In all these cases the fistulas healed.

It is our custom to approach cases for ileocolostomy with exclusion through a left-sided incision as the usual site of fistulas due to operations for suspected appendicitis is on the right side. If resection is proposed, the approach is through the right side, unless the condition of the skin prohibits such an incision. In a recent case the condition of the entire lower abdomen was such that an approach below the umbilicus was impossible (Figs. 1 and 2). A transverse incision above the umbilicus was finally resorted to, and offered adequate exposure for the enterocolostomy with exclusion, which was performed. In some instances, in order to preclude the possibility of division and anastomosis at too high a level in the small bowel, we have traced the small bowel down from the duodenojejunal flexure. For the actual anastomosis we have usually preferred a side-to-side ileotransverse colostomy with closure of both ends of the divided ileum. When resection is performed, it is carried distally to include the cecum. Resection of the entire ascending colon is not as a rule necessary. Because of the lack of peritoneum on the posterior aspect of the ascending colon, we have usually drained

the colonic suture line. With resection we prefer also to place the ileocolostomy in the transverse colon. In spite of the formidable technical difficulties encountered at times, the mortality in resection is low, perhaps due to the peritoneal immunity acquired as a result of the long-standing inflammatory process. However, in a large series of cases we feel that an occasional mortality will probably be avoided if a simple enterocolostomy with exclusion is performed. The conservative attitude would appear to be the performance of such an ileocolostomy with exclusion as a first stage. Viewing subsequent conditions with an open mind, the necessity for further operation would be determined by the effect of the initial procedure on the subsequent progress of the disease.

Recurrence of ileitis proximal to the level of the ileocolostomy subsequent either to exclusion or resection is of great importance. Such recurrence or persistence of the disease was encountered twice, once after exclusion and once after resection. These cases stress the necessity of constantly bearing in mind the possibility of so-called "skip areas"; i.e., normal segments of bowel between two diseased areas. This area of normal bowel may be a number of feet in length. Furthermore, in order to be safe, division of the ileum should be performed at least one foot proximal to the site of grossly discernible disease. These two factors will probably diminish, but not entirely prevent, the possibility of proximal recurrence at a later date. This element in prognosis is really part of the question of recurrence in regional ileitis in general, a problem which is proving increasingly vexing. Of these 2 cases, the one which recurred after enterocolostomy with exclusion has been well for eight years, following secondary resection. The patient in whom recurrence took place after primary resection has remained well for three years following a secondary exclusion operation. One patient in whom resection was performed recovered from her ileitis, was well for a number of years, then developed a diffuse ulcerative colitis.

To sum up, the course of the 14 cases with fecal fistulas due to regional ileitis was as follows: Two died from extensive retroperitoneal suppuration. One of these occurred before the nature of the disease was understood, and the other patient was too sick to permit of any short-circuiting procedure. Another died from an intestinal leak and exhaustion following a complicated resection. There were no deaths following enterocolostomy with exclusion. Of the 11 patients who are alive, 10 are well (2 after secondary resection for proximal recurrences) and 1 is suffering from diffuse ulcerative colitis.

SUMMARY AND CONCLUSION

1. A study of chronic fecal fistulas at the Mount Sinai Hospital revealed that regional ileitis is a common cause of this condition.

2. The reasons for the confusion of fistulas due to regional ileitis with those due to appendicitis are reviewed and the clinical and pathologic differences between them are noted.

3. The clinical and pathologic course of that type of ileitis manifesting itself by intra-abdominal suppuration and external fistula formation is described in further detail.

4. Fecal fistulas in cases of regional ileitis with suppuration do not originate primarily in an appendix stump, but in the ulcerative lesions present in the bowel. Secondary fistulas, however, may originate at the site of the appendix stump.

5. The limitations and advantages of various methods of treatment are discussed.

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The author also wishes to thank Dr. J. H. Globus for permission to reproduce Fig. 3.

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CONGENITAL ANOMALIES OF THE ANUS AND RECTUM

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CONGENITAL malformations of the anus and rectum may constitute an immediate danger to the life of the patient. They may cause no impairment of general health, or they may become a source of complications in later life. Their management is not difficult if based on a clear understanding of the embryology and anatomy of the various forms.

These deformities occur about once in every 10,000 births, according to Allen,[1] David,[2] Gant,[3] and others. Among the 150,354 patients admitted to the University of Iowa Hospitals during the past twelve years, there have been 28 cases of anorectal anomalies, or approximately 1 in 5,300 admissions.

Imperforate anus was recognized by Paulus, of Aegina, who in the seventh century described an operation for its relief. He passed a bistoury through the perineum and later dilated the opening with bougies. In 1640, Scultet reported a case of congenital anal stenosis successfully dilated with gentian roots. Saviard, in 1693, recorded the case of a patient with a bulging membranous closure of the rectum that he treated with a bistoury and subsequent dilatation. This method was practiced with little variation until Amussat,[4] in 1835, recommended proctoplasty by dissection and mobilization of the rectal pouch to the proper site. In 1844 French surgeons advised inguinal colostomy when perineal exploration failed. The first successful operation for imperforate anus in the United States was performed by Campbell in 1790. Bodenhamer,[5] in 1860, published an exhaustive treatise on anorectal anomalies and presented 287 cases. In 1887, Cripps[6] reported 100 operated cases with a mortality rate of 50 per cent. By 1915 the mortality had been reduced to 25 per cent in Brenner's[7] series and there has been no appreciable change since.

A review of the normal embryological development of the region is necessary if we are to understand the pathogenesis of these anomalies. Most of them are due to arrests or abnormalities of development arising in the seventh or eighth week of embryonic life. In the embryo of six weeks the cloaca is divided longitudinally by a downgrowth of the urorectal septum, but for a time there is a small opening between the urogenital tract and the hind-gut, which is known as the cloacal duct. The failure of the cloacal duct to close accounts for the anomalous connections between the urinary tract and rectum. The Müllerian ducts, as they migrate caudad at the expense of the posterior wall of

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the urogenital sinus, may incorporate the cloacal duct. This explains the formation of communications between the rectum and the genital tract in the female.

The rectum is separated from the external surface in early embryonic life by the anal membrane. During the seventh week a small depression, the proctodeum, appears and pushes upward until it joins the rectum by rupture of the anal membrane. Congenital anal stenosis results from incomplete rupture of the membrane. Persistence of the membrane produces an imperforate anus.

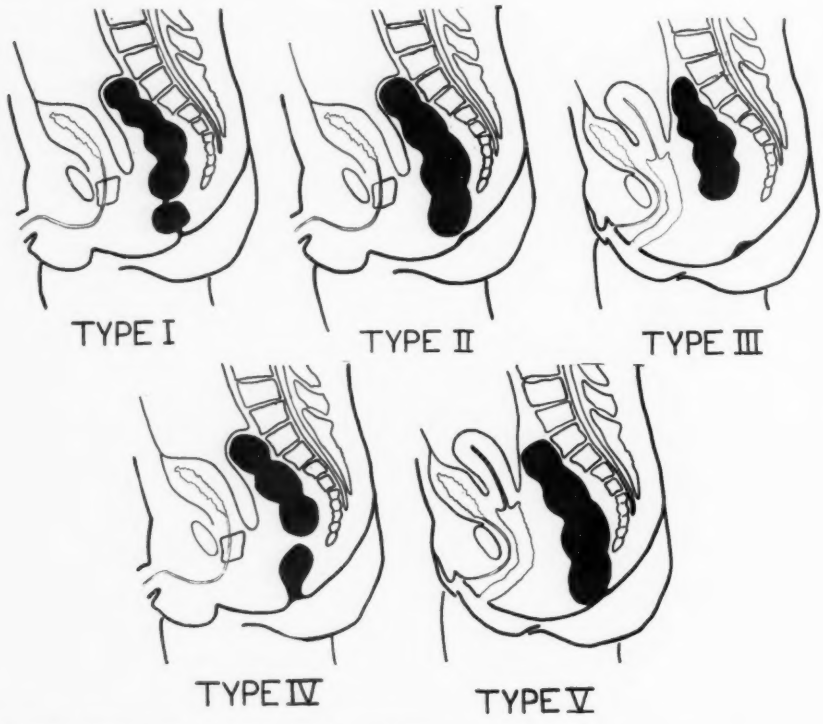

Fig. 1.—Types of anorectal malformations.

Type I, incomplete rupture of the anal membrane or stenosis at a point 1 to 4 cm. above the anus; *Type II,* membranous imperforate anus; *Type III,* imperforate anus with rectal pouch separate from it; *Type IV,* normal anus and anal pouch, rectal pouch ending blindly; *Type V,* partial or complete absence of the anal sphincter.

Anomalies in which the rectum ends blindly at a considerable distance above the perineum are due to excessive degeneration of the tail-gut. This produces a deficiency in the lower posterior portion of the cloaca. As a result the rectal pouch is left isolated from the external surface when division of the cloaca occurs. Since the external anal sphincter muscle develops from regional mesenchymal tissue, and is not dependent on the presence of the hind-gut, it is relatively normal in most types of anorectal malformations.

Congenital anomalies of the anus and rectum may be classified in several ways. The classification offered by Wood-Jones[8] is on an

embryological basis, while that of Fraser[9] and that of Drueck[10] are according to anatomical variations. Our classification is similar to the grouping of Ladd and Gross.[11] The various types of anomalies are illustrated in Fig. 1.

Fistulas between the rectum and the genitourinary system or perineum occur in combination with the above types. In the male the fistulas may be rectovesical, rectourethral, or rectoperineal. In the female the fistulas usually communicate with the genital tract. Fig. 2 shows the common forms of fistulous communications.

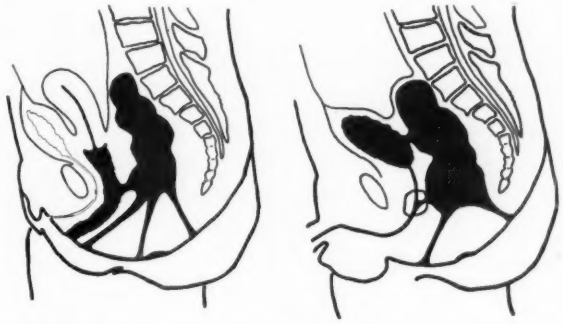

Fig. 2.—Left, common types of congenital fistulas occurring in females; right, fistulas in males.

The symptoms of anorectal malformations are varied. Chronic constipation is produced by congenital anal stenosis. This condition is thought by some to occur much more frequently than the other anomalies. Webb[12] noted four cases of anal stenosis in 150 consecutive deliveries. The passage of formed stools may dilate many of these membranous stenoses. The infant with complete occlusion of the anus or rectum usually takes feedings until the second day when symptoms and signs of intestinal obstruction appear, accompanied by dehydration. The absence of bowel movements may direct the parent's attention to the condition. If a small fistula is present, symptoms of a partial intestinal obstruction occur, and meconium is discharged from an abnormal location. Fistulas between the rectum and urinary tract are usually discovered because of the passage of meconium or gas in the urine. In these patients ascending urinary tract infection, with associated symptoms, is almost inevitable.

Careful examination will reveal the type of anomaly present. The dark discoloration of the membranous imperforate anus is due to underlying meconium. A small dimple is often observed at the normal anal site. Puckering of the skin, due to contraction of the anal sphincter, may be demonstrated by local stimulation. In the presence of a normal anus, digital examination may reveal an occlusion of the rectum. Inspection of the fundus of the anal pouch may be accomplished through an ear speculum.

Roentgenographic examination is an important diagnostic procedure. Wangensteen and Rice[13] recommended visualization of the rectal pouch in the roentgenogram by allowing gas to outline the lower bowel. This is best accomplished by holding the child in the inverted position. Any gas which is present in the colon may be forced into the rectum by gentle massage of the abdomen. This procedure is impractical during the first twenty-four hours of life, since gas does not form until the second day.

Fistulous tracts may be injected with a radiopaque substance and roentgenograms taken to show the termination of the large bowel. In patients who have had a colostomy, the distal loop may be visualized by the same method to demonstrate fistulous communications and the position of the rectal pouch.

The treatment of some anorectal malformations is simple. Repeated digital dilatation of the anal or rectal stenoses is usually sufficient to restore normal function, but occasional cases with partial membranous occlusion are best treated by incision or excision of the diaphragm-like structure. Membranous imperforate anus is easily treated by simple cruciate incision followed by occasional dilation.

There are definite indications for primary colostomy and for proctoplasty in the treatment of the more complex types of deformities. The majority of writers since the publications of Amussat[4] favor proctoplasty in all cases. This is the ideal operation because it immediately creates an anal opening in the normal location. When definite bulging of the rectal pouch in the perineum is found, proctoplasty is indicated, even when symptoms of intestinal obstruction are present. The procedure may be technically difficult in the newborn and the poor condition of many of these patients often contraindicates long difficult operations. Colostomy is the treatment of choice when the infant is dehydrated, distended, and tympanitic, and when there is no evidence of perineal proximity of the rectal pouch.

The proctoplasty is performed by making a longitudinal incision from the anterior portion of the perineum to the tip of the coccyx, dividing the anal sphincter into two lateral halves. A sound is placed in the vagina or male urethra to prevent injury to these structures. Dissection is carried upward through the levator ani, staying close to the sacrum. The rectal pouch is identified and freed from surrounding structures, care being taken not to damage the superior hemorrhoidal vessels. If the segment is short, it is necessary to carry the dissection up to the peritoneum before satisfactory mobilization of the rectal pouch to the perineum can be accomplished. Occasionally it is necessary to open the peritoneum when the bowel terminates at the pelvic floor. After suturing the levator ani and anal sphincter anteriorly, the bowel is opened and loosely sutured to the skin. Reconstruction of the posterior portion of the pelvic floor and sphincter is then completed.

Anorectal malformations associated with rectovaginal, rectovulval, or rectoperineal fistulas usually do not require immediate colostomy or proctoplasty. The fistulous openings are often of sufficient size to allow emptying of the bowel. A channel of inadequate size may be dilated to serve as an outlet for bowel contents, allowing postponement of the proctoplasty until the anatomic structures are more completely developed and easier to deal with..

The operative technique used in the treatment of rectovaginal or rectoperineal fistulas is dependent on the size of the fistulous opening. A small fistulous tract is excised, the openings closed, and the rectal pouch transplanted to the anal region. The fistulous tract large enough to allow adequate passage of feces is mobilized to the normal anal site. Following this, reconstruction of the perineum and anal sphincter is carried out.

Communications between the rectum and urinary tract are the most difficult to treat successfully. If an opening into the urethra is present, it should be closed and a proctoplasty performed. In patients with rectovesical fistulas, early colostomy is necessary. No attempt should be made to close the fistula or establish a normal anus until the pelvic structures are well developed.

In our series, 16 patients were males and 12 were females. Associated fistulas were present in 17 instances. Table I shows the distribution of the various types according to their sex and the presence or absence of fistulas. It is evident in the table that Type III is the most common anomaly and is most frequently associated with fistulas.

TABLE I

DISTRIBUTION OF THE FIVE TYPES OF ANOMALIES IN REGARD TO SEX AND PRESENCE OR ABSENCE OF FISTULAS

TYPE OF ANOMALY	MALE	FEMALE	FISTULA	NO FISTULA
Type I	2	1	0	3
Type II	5	1	2	4
Type III	8	8	13	3
Type IV	1	0	1	0
Type V	0	2	1	1
Totals	16	12	17	11

The types of fistulous communications are summarized in Table II. The significant feature of this table is the absence of instances of connections between the rectum and the urinary tract in females.

TABLE II

TYPES OF FISTULAS IN MALES AND FEMALES

TYPE	NO. OF CASES AND SEX	
Rectovesical	3	Male
Rectourethral	1	Male
Rectoperineal	3	Male
Rectovulval	4	Female
Rectovaginal	6	Female

Associated congenital malformations were found in 13 cases, or 46 per cent. These conditions may constitute the major problem in care of the patient. Eighteen different types of anomalies were noted, the most frequent being congenital clubfoot and deformities of the hand.

Our methods of treatment of each type of malformation with the corresponding results are given in Table III. Only patients in whom normal function of the anus and rectum has been restored are classified as "cured." All of the patients in the "improved" group have been relieved of their intestinal obstruction but continue to have some type of anal or rectal dysfunction. Stricture of varying degree is present in 6 patients. The same number complain of unsatisfactory control of the sphincter.

TABLE III

SUMMARY OF METHODS OF TREATMENT WITH RESULTS

TYPES AND TREATMENT	CURED	IMPROVED	UNIMPROVED	UNKNOWN
Type I				
Repeated dilatations		1	1	1
Type II				
Incision alone			1*	
Incision followed by dilatation	1	3		
Unsuccessful incision followed by colostomy		1		
Type III				
Proctoplasty	3	3	1*	
Unsuccessful proctoplasty followed by colostomy		3	2*	
Primary colostomy		1		
Medical treatment			2	
No treatment			1	
Type IV				
Proctoplasty followed by dilatations		1		
Type V				
No surgical treatment			2	
Totals	4	13	10	1

*Operative deaths.

The tracts have been successfully closed in 5 of the 17 patients with associated rectal fistulas. Healing occurred in 2 of 3 patients on whom operative closure of the fistulous tract was performed. Spontaneous closure of a rectovesical fistula took place following a colostomy. Proctoplasties alone closed a rectoperineal and a rectourethral fistula. Two rectovulval fistulas without obstruction or incontinence were not disturbed. Operative repair has been postponed, because of age, in 2 patients with rectovaginal communications. In the remaining 8 patients the fistulas have persisted following proctoplasty or colostomy.

Twenty-three cases were treated surgically with 4 operative fatalities, a surgical mortality of 17 per cent. Two patients have subsequently

TABLE IV

SUMMARY OF RESULTS OF SURGICAL TREATMENT (23 CASES)

TYPE	RECOVERED			DIED POST-OPERATIVELY	RESULT UNKNOWN
	GOOD	FAIR	POOR		
I		1	1		1
II	2	2	1	1	
III	3	6	1	3	
IV	1				
Totals	6	9	3	4	1
	15 (65.2%) satisfactory		7 (30.4%) unsatisfactory		

died, one of congenital heart disease and the other of intestinal obstruction due to dietary indiscretion. The result of 1 case is unknown.

The follow-up study of the results of surgical treatment is summarized in Table IV. Combining the "good" and "fair" results, 65.2 per cent were satisfactorily treated.

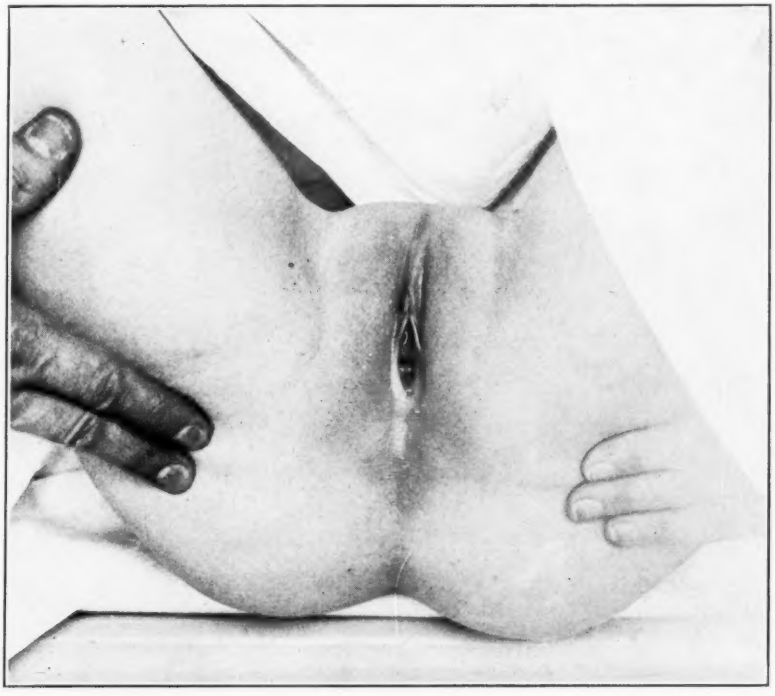

Fig. 3.—Photograph of the patient before operation. Note absence of anus with small dimple in the anal region.

CASE REPORT

A typical case of Type III anomaly and associated rectovaginal fistula is presented.

D. F., No. B-8005, a white female patient, aged 13 years, was admitted to the hospital complaining of difficulty in controlling the bowels. All of her life she had been troubled by partial fecal incontinence when the stools were liquid.

The physical examination revealed a poorly developed right thumb and wrist. There was no anal opening, but a small dimple was noted in this area (Fig. 3). Contraction of the anal sphincter could not be demonstrated. Vaginal examination revealed a rectal fistulous opening, 2.5 cm. in diameter, situated posteriorly and just above the fourchette. The vagina and lower bowel were filled with feces. After thorough cleansing with enemas and douches, the rectum was filled with barium and roentgenographic studies were made. The large dilated rectal ampulla ended 3 cm. above the perineum (Fig. 4).

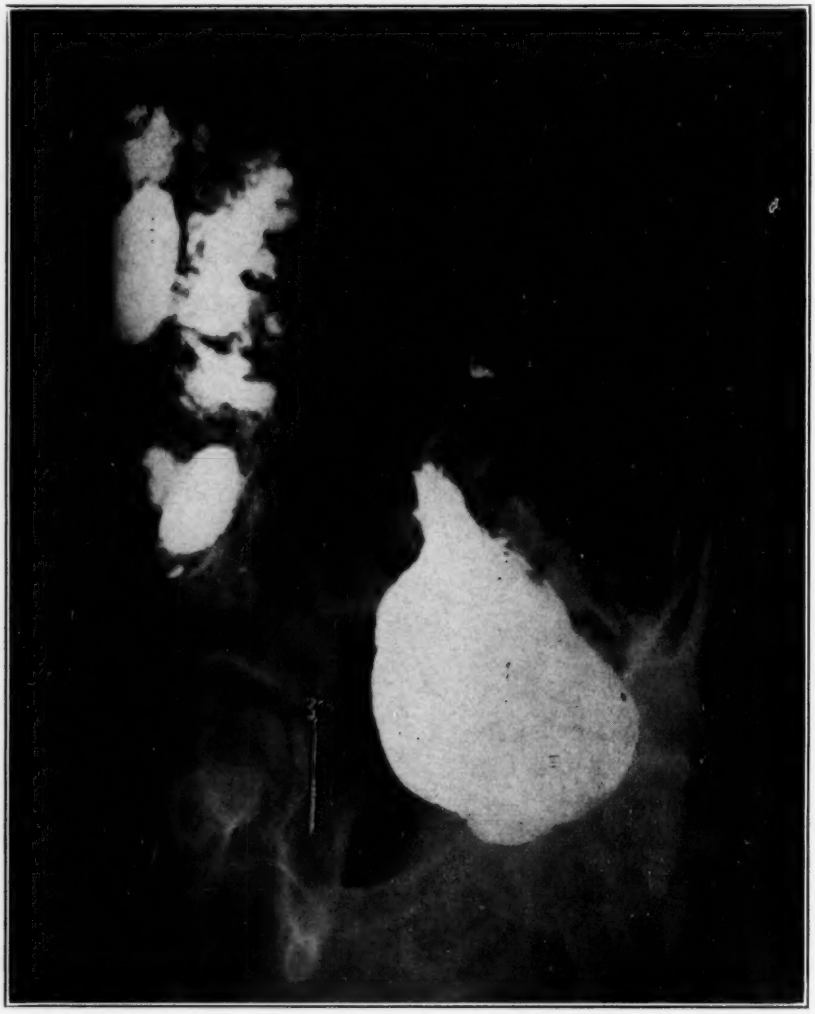

Fig. 4.—Roentgenogram showing the dilated, barium-filled rectal pouch 3 cm. above the perineum.

Preoperatively, the patient was given a low residue diet, daily enemas and antiseptic douches. Sixteen days after admission, under ethylene anesthesia, a proctoplasty was performed. An elliptical incision around the vaginal fistulous opening was made and the rectal wall freed for a distance of 6 cm. The skin was incised from the fourchette posteriorly to the coccygeal region with an elliptical piece of skin excised at the normal anal site. A hemostat was inserted through

the muscle fibers of the anal sphincter and the freed rectum with its vaginal opening brought down through the newly formed tunnel. The rectal mucosa was then loosely sutured to the skin. The operation was completed by suturing the vaginal wall defect and closing the skin incision. The postoperative treatment consisted of a clear liquid diet and powdered opium for five days. The operative wounds healed well and the patient was discharged on the fifteenth postoperative day. She returned to the hospital for final examination seven months after the operation. Her bowels had moved daily and there was good sphincter control. Examination showed the anus and perineum to be well healed with no evidence of stricture or recurrence of the rectovaginal fistula (Fig. 5).

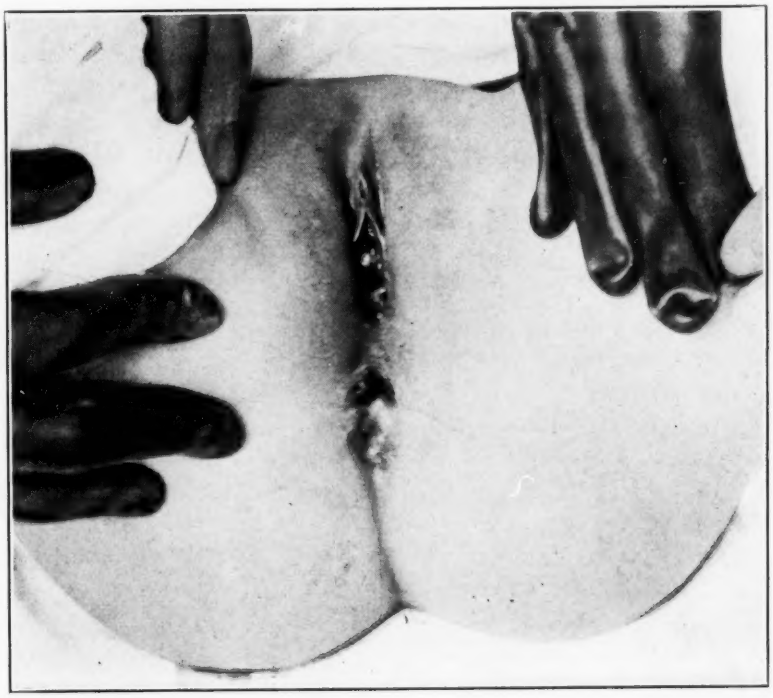

Fig. 5.—Photograph taken seven months after operation. Normal rectal function has been restored.

DISCUSSION

Anorectal anomalies are uncommon, but a surgeon may be required to care for such a patient at any time. In order to be able to manage these problems properly he must have a working knowledge of the embryology responsible for the various types of defects. All cases can be classified into five types of malformations, each requiring different methods of treatment.

Congenital malformations of this region should be suspected in infants presenting symptoms and signs of complete or partial intestinal obstruction. When an associated fistula sufficient in size to allow passage of the fecal stream is present, the true condition may not be recognized. Regional examination will make the diagnosis. Valuable information may be obtained by the use of properly taken roentgeno-

grams. These studies are of greatest value in determining the position of the blind rectal pouch. When fistulous tracts are present, their course and relationship to the bowel can be visualized with radiopaque substances.

We believe that the present high mortality in these patients can be reduced only when the surgeon realizes that the relief of the obstruction is the most important part of the treatment. In the debilitated infant with a high-lying rectal pouch the performance of a double-barreled colostomy is the safest procedure. In such circumstances the colostomy is not only lifesaving but is of value in allowing subsequent visualization of the distal, blind loop of bowel. Primary colostomy is always indicated when a rectovesical fistula is present. At a later date, when the patient's general condition is satisfactory and the anatomical structures are more fully developed, plastic procedures may be performed. It is desirable to delay complicated reconstructive procedures until the patient is 8 or 10 years of age. Even after long periods of nonuse, proper utilization of the anal sphincters usually results in satisfactory bowel control. Many fistulous tracts will close spontaneously after a satisfactory proctoplasty or colostomy. The complete relief of bowel obstruction is a prerequisite for the successful operative closure of a fistula. It must be remembered that an adequate fistulous opening without incontinence is preferable to a malfunctioning, normally located anus.

SUMMARY

1. The embryology of the anus and rectum has been briefly discussed.

2. The anomalies have been classified into five types.

3. Methods of examination including roentgenographic studies have been described.

4. Indications for proctoplasty and colostomy have been given.

5. Twenty-eight cases of congenital anorectal anomalies treated in the University of Iowa Hospitals have been reviewed.

6. A satisfactory result was obtained in 65.2 per cent of the surgically treated patients.

7. There was a surgical mortality of 17 per cent.

8. A representative case has been briefly reported.

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LYMPHOID TUMORS OF THE COLON AND RECTUM

Report of a Case of Simple Lymphoma of the Rectum

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WHEN one begins a review of the literature on tumors of the lymphatic system, he is immediately impressed by an apparently hopeless confusion regarding nomenclature. Then there is a marked difference of opinion concerning etiology, morphology, and histogenesis. Ewing,[1] who is generally accepted as an authority on tumors, says that "the complexities of the subject of lymphoid tumors depend chiefly upon the lack of knowledge of etiology and partly upon the lack of accurate anatomical classification." He gives an excellent classification according to histogenesis and states that the three elements that may originate lymphoid tumors are: (1) lymphocytes, (2) reticulum cells of follicles and pulp, and (3) endothelial cells of pulp and cavernous sinuses.

LYMPHOSARCOMA

The most common lymphoid tumor of the large bowel is the lymphosarcoma, which is also called the small or large round-cell sarcoma. It has also been called lymphoblastoma, malignant lymphoma, lymphocytoma, granulomatous pseudoleucemia, intestinal Hodgkin's disease, and lymphoid granulation tumor. Is it no wonder that a compilation of reported cases is most difficult? A total of 371 cases of lymphoid tumors of the colon and rectum were found in the literature, of which 340 were called lymphosarcoma.[2-18] Ullman and Abeshouse have written an exhaustive study of lymphosarcoma of the intestines and find that in the colon the cecum, first, then the rectum are most frequently involved. All are agreed that metastases occur early and that the only hope of a cure is early radical removal followed by irradiation.

LYMPHOBLASTOMA

According to Martin,[19] the term lymphoblastoma is used at the Massachusetts General Hospital to include lymphogranuloma, lymphosarcoma, lymphoma, leucemia, and aleucemia. He reported nineteen cases, 5 of which involved the colon as part of a generalized intestinal involvement, while one involved the rectum alone. In this case examination showed "cartilaginous" thickenings of the rectal valves "associated with numerous ulcers which did not resemble cancer." Treatment with x-ray at four-month intervals for two and one-half years gave complete relief of symptoms.

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Raiford[20] reported forty-five cases of lymphoblastoma of the gastrointestinal tract seen at Johns Hopkins Hospital. Of these, one was in the sigmoid and one in the rectum. He called the latter two a "malignant reticuloma" which he defines as a "reticulum cell sarcoma" or a "malignant neoplasia of the reticulum cells of the follicles and sinuses." This may be what other authors have called a large-cell lymphosarcoma.

LYMPHOGRANULOMA

Six reported cases of lymphogranuloma (Hodgkin's disease) of the large bowel were found in the literature. Hayden and Apfelbach[21] reported four, including one of their own; Pape[23] reported one and Liebig[22] reported one. Hayden and Apfelbach say that the typical changes of lymphogranuloma are not always observed in the intestinal lesions and a diagnosis is made from the lymph glands. However, the latter may show only hyperplasia, and the typical findings are then in the bowel wall.

LYMPHANGIOMA

The recent literature contains two reports of lymphangioma of the rectum.[24, 25] It is described as a fibrous stroma containing many arterioles and dilated veins. One was a "small tumor"; the other was pedunculated.

LYMPHOMA (LYMPHADENOMA)

These terms are used interchangeably by Ewing to designate a benign lymphoid tumor. It is usually polypoid and occurs chiefly in the rectum. It is a hyperplasia of the lymphoid tissue in the submucosa that pushes before it the normal mucosa. It is thought that the term lymphoma is a better word since the word or suffix adenoma is usually applied to an epithelial tumor whose cells line glandlike depressions or cavities in the stroma.

We found twenty such reported instances;[26-35] some were called lymphoma and others lymphadenoma. They were nearly all single or multiple polypi. One patient had an annular stricture of the rectum due to infiltration of the wall by the tumor. Some were treated by resection of the rectum and others with x-ray and radium with uniformly good results. In no instance was the high frequency electric current used. Billaud and co-workers[36] reported a case which they called lymphocytoma. In this instance numerous rectal tumors occurred two years after an identical condition of the tonsils. The x-ray cured both conditions. This may well have been a simple lymphoma since the response to x-ray was so pronounced. Ewing classifies simple lymphoma as one of the clinical types of lymphoid tumors of which the lymphocytoma is the anatomical type. The other clinical types he includes in the term lymphocytoma are tuberculous lymphoma, lymphatic leucemia, pseudoleucemia, and malignant lymphocytoma.

We would like to report a case of simple lymphoma of the rectum that has a few interesting features.

CASE REPORT.—Mrs. A. C. E., aged 31 years, consulted one of us (L. T. P.) on Feb. 4, 1937, complaining of headaches, vertigo, nausea, dyspnea on mild exertion or lying flat, and pains around the heart. Family history, past history, menstrual and marital histories were irrelevant.

She had had some trouble with her heart following pneumonia; it had been said to be "weak." She had palpitation at times, as well as weakness and choking spells. On excitement or exertion there was dull pain in the left chest which radiated down the right arm, making it numb, and to a less degree down the left arm. Smothering attacks occurred at night, for which she had to sit up in order to obtain relief. There was slight edema of the ankles in the late afternoon. There was no cough, hemoptysis, or asthma.

Her appetite was good. For ten years she had had stomach trouble which had become worse the past several weeks. She had "burning" in stomach soon after eating and spit up food which set her teeth "on edge." Sometimes after eating she became nauseated and vomited food. Soreness in upper abdomen and sometimes under the right shoulder blade was present. No jaundice, cramps, diarrhea, or blood in stool was present. She has chronic constipation, for which she takes bile salts tablets.

Genitourinary-system findings were negative.

General physical examination disclosed essentially normal findings. It is interesting and essential to know that there was no lymphadenopathy.

Rectal examination showed a chronic anterior anal fissure. The anus was moderately contracted. About 8 cm. from anal margin, there was a mass on the right side of the rectum about 2.5 by 2.5 cm. which protruded 1.5 cm. into the lumen of the bowel. It was firm, not tender, and freely movable. There was a smaller polyp the size of a pea just below this growth. There were several small internal hemorrhoids.

During proctoscopic examination, the above-described tumors could be easily seen. The mucosa appeared normal. There was no ulceration or bleeding. Above the large growth, 16 cm. from the anus, there was another polypoid tumor about 0.5 cm. in diameter.

Urinalysis, blood count, gastric analysis, electrocardiogram, and basal metabolic rate were normal.

X-rays of the chest, stomach, and gall bladder disclosed normal findings.

X-ray of the colon showed: "Excess mucus in its distal half. At twenty-four hours colon is empty. Double contrast enema shows an area of the colon from splenic flexure to and including a part of sigmoid colon that is very irritable, its walls shaggy looking with patches of adherent barium scattered throughout this area. When the colon is distended with air, the patches are circumscribed and appear to be organic lesions—ulcers or polyps. Two small polyps are seen in lower part of descending colon."

The patient was advised to have the accessible growths destroyed by fulguration and x-ray treatments given the remainder of the colon.

On March 25, 1937, the small polyp at the rectosigmoid was destroyed by fulguration. This was an office procedure. She was sent to the hospital where, under a spinal anesthetic, the large growth was fulgurated the next day until it was flat with the rectal wall. Several pieces of tissue were first removed for microscopic study. At this sitting a cervical dilatation and curretage of the uterus was done by Dr. F. J. Iiams. Convalescence was uneventful and she left the hospital nine days later.

One month after the operation six radon seeds were implanted in the rectal wall by Dr. C. M. Griswold at the previous site of the large tumor, which latter appeared to be healing rapidly. The radon seeds were removed seven days later. Proctoscopic examination three weeks after the radon seeds were implanted showed that there was no evidence of the growth and that the site of fulguration was covered with healthy mucosa. At this time another very small polyp at the rectosigmoid was destroyed with the actual cautery.

Fluoroscopy of the colon in September, 1937, six months after the operation, confirmed the previous findings of a few polyps in the distal transverse and descending colon. Accordingly she was given five x-ray treatments in ten days by Dr. R. E. Barr, of Beaumont, Tex., during the first part of October, 1937. She was given a total dose of 1,480 r. with 200 kv., 50 cm. distance, ¾ Cu plus 2 Al, divided 720 r. anteriorly and 720 r. posteriorly. The uterus and remaining ovary were screened.

There was a marked diversity of opinion among the pathologists who studied microscopic sections of the large tumor. Dr. Martha A. Wood, of Houston, Tex., made a diagnosis of "nonmalignant chronic inflamed mucosa with lymphoid tissue beneath." Her report states: "Tissue from upper part of lesion shows much lymphoid tissue beneath the mucosa. The mucosa is ragged and degenerated. No evidence of malignant changes."

Dr. L. A. Myers, of the Memorial Hospital, Houston, Tex., made a diagnosis of "simple lymphoma, apparently of low grade chronic inflammatory origin." Following is his report: "The mass is composed of rather moderately hypertrophied lymph follicles surrounded by normal fibrous tissue with a moderate degree of inflammatory infiltration, predominantly the small round-cell type. The lymphoid follicles are made up of orderly differentiated lymph cells with practically no acute inflammatory manifestations. There is very little evidence of fibrosis. No multinuclear giant cells or Dorothy Reed cells were noted."

Dr. Violet Keiller, of the Hermann Hospital, Houston, Tex., called it a "medullary carcinoma of the rectum." She says: "Slide shows a small area of glandular epithelium. Immediately beneath this infiltrating between the muscular layers is a very cellular tumor. From the first slide examined this was thought to be lymphoblastomatous in character. More preparations were made from one of the small pieces of tissue and I believe that in these the origin from glandular epithelium can be traced. The cells of the tumor are so atypical that no glandular character is present, but I believe that the vacuolization in some areas is an indication of mucus production."

Dr. Joseph Felsen, of New York, N. Y., examined the tissue on two occasions. The first time he "felt certain the case falls within one of two groups: (1) atypical Hodgkin's disease, or (2) diffuse lymphoma of the type described by Symmers many years ago." He says in the second report that the "tissue impresses me with the possibility that this is an atypical form of Hodgkin's disease. In one section reticu-

lum cell hyperplasia is very marked. Many eosinophiles are present and some suggestive Dorothy Reed cells. The lesion appears to be in both the moderately advanced and fibrotic stages."

Dr. Fred W. Stewart, of the Memorial Hospital, New York, N. Y., says: "Were this a solitary lesion one might be inclined to regard it as a simple lymphoma. With the presence of multiple polypoid lesions shown by radiographs, I fear the process must be regarded as a part of a generalized intestinal lymphomatosis and that the disease may be expected to run a slow but eventually malignant course with extension to abdominal and other lymphoid tissues. Symptomatic x-ray treatment may control it for a considerable period."

Dr. James Ewing, of the Memorial Hospital, New York, N. Y., states: "I wish to confirm the report sent by Dr. Stewart on the lymphoid tumor of the rectum. Whether this is true tumor lymphoma or granuloma I find impossible to decide and perhaps the distinction is not important. I would certainly carry out a program of x-ray treatment and would also suggest a series of high soapsuds enemas to cleanse the colon thoroughly."

The picture as presented by the pathologists is rather confusing, but the majority have called it a lymphoma or lymphomatosis. It was practically impossible to obtain a section of the smaller lesions because, after the current was applied, there remained nothing to section. The entire disappearance of all smaller lesions after x-ray or fulguration and the excellent result obtained on the large growth by fulguration and radium is further clinical evidence that the condition is lymphoma or lymphomatosis.

It is now two years since the operation and the patient has remained in good health. Two x-ray examinations of the colon, one very recent, with double contrast enema disclosed a normal colon. Six proctoscopic examinations during this time showed a normal rectal mucosa.

SUMMARY

1. The literature on lymphoid tumors of the colon and rectum has been reviewed.

2. One case of simple lymphoma of the rectum is added to the twenty found reported in the literature.

3. Treatment consisting of local fulguration and radium together with deep x-ray over the colon has resulted in an apparent cure for over two years.

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INFECTIONS OF THE HAND FOLLOWING HUMAN BITES

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HUMAN bites of the hand, although not a common type of injury, are frequently followed by a marked loss of function or amputation of the digit due to the complicating infection. Because early diagnosis and treatment give so much better results than delayed treatment, it seems justifiable once more to emphasize this point and to add the experience gained in the treatment of these cases at the San Francisco Hospital in the past eight years.

There are only two large series of cases described in the literature. Bates[1] states that he has had only one amputation in his last 100 cases in which he has excised the wound at once with the electrocautery. The amputation occurred in a patient who had sustained a fracture of the metacarpal as well. The other cases are not reported. Lowry[17] has had 93 bites of the fingers and hand. He treats the wound at once with fuming nitric acid and then washes the wound with water. This treatment is applied when the tendon is cut or joint capsule torn. He states that in 55 cases followed long enough to know the end results, 53 have had "good results." Case reports are not given. Welch,[2] in an excellent clinical paper, reports 18 cases in detail from the Massachusetts General Hospital. He classified his patients according to the elapsed time before entry and charted the cases reported in the literature. His classification will be used in this report. Mason and Koch[3] reported 13 cases. In addition they studied the course of infection from the dorsum of the hand by the injection mass method. Excellent drawings are given in their paper. Additional cases have been reported by Flick,[4] Bower and Lang,[5] Dimtza,[6] Frankenthal,[7] Pilot and Meyer,[8] Hudacsek,[9] Peters,[10] Fuller and Cottrell,[11] Hennessey and Fletcher,[12] and Hultgen.[13]

The clinical course, as Welch points out, is remarkably constant. The patient is usually a man who has struck another in the mouth during a fight, injuring the region over the metacarpophalangeal joint. After an interval of twelve to twenty-four hours, the hand becomes swollen and painful and the wound begins to discharge pus. Mild constitutional symptoms are present. About three or four days after the original injury, the patient appears at the hospital.

On questioning he may deny that he received a bite, but the location and the small jagged laceration, obviously made by something blunt, should make one suspicious. The hand is usually swollen, most mark-

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edly on the dorsum. There is an area of cellulitis about the wound and the pus draining from it may be foul. Sometimes lymphangitis is also present. If the joint is involved, the finger is very painful on motion.

Smears of the pus may show the mixed organisms found in the mouth. The most important of these are the spirochetes and the fusiform bacilli. Streptococci and staphylococci are also commonly found but the presence of the spirochetes and fusiform bacilli usually indicates a poor prognosis. Cultures should not be regarded as negative unless anaerobic cultures have been made in addition to the routine cultures.

If the injury is seen immediately and if one is absolutely certain that the skin has not been penetrated, local cauterization with nitric acid is permissible. Dunn[16] and Lowry[17] recommend this procedure for all types of bites of the hand.

We prefer to admit the patient to the hospital, and, under general anesthesia and a tourniquet on the arm, we excise the local wound. If examination of the extensor tendon and joint capsule shows them to be intact, the wound is packed lightly and the hand and arm splinted and the patient kept in the ward. If, after forty-eight hours, no infection becomes apparent, he is discharged to a follow-up clinic.

If the tendon and joint capsule have been injured, the area should be excised and the joint capsule widely opened. Welch favors cutting the lateral ligaments and the web spaces on either side as well. It is necessary to cut the extensor tendon as it will fall back and obstruct drainage of the joint. Boric and vaseline gauzes should not be used as packs as they favor anaerobiasis.

If the patient is seen when infection is already established, that is, more than twenty-four hours after injury, we believe that the treatment should be conservative. The hand should be splinted and warm wet poultices applied. The lymphangitis and cellulitis will recede. If an abscess localizes, it should be drained. These localized abscesses may possibly be due to inoculation of the intermetacarpophalangeal bursae which lie at the metacarpal heads dorsal to the transverse capitular ligaments, between the second and fifth fingers.[18]

If the joint is involved on entry, the heads of the metacarpals soon become involved. Characteristic x-ray evidence of osteomyelitis appears and the wound continues to discharge pus. Even if the finger is saved, it will be stiff and of questionable value.

Occasionally the infection may rupture anteriorly and a tendon sheath infection result as in Welch's Case 9. If the bite has been over a terminal joint, the tendon sheath may be inoculated directly as in Case 20 of the series reported here. By way of the lumbrical canals the thenar or midpalmar spaces may be involved.

When the metacarpophalangeal joint is involved and there is osteomyelitis of the metacarpal head, amputation should be done through the metacarpal head. The cartilage should always be removed.

Postoperatively, the splinting should be continued. The dorsum should be directed downwards to promote drainage by gravity. Sterile hand soaks can be used with benefit. This should not be continued for more than a few days because of the resulting maceration and edema. The solution used is not considered of much importance. Saline solution or potassium permanganate 1/1,000 is satisfactory. Dakin's solution is somewhat painful, especially in the acute stages.

The use of arsenicals intravenously has not been demonstrated to have any effect other than to deodorize the wound when spirochetes are present. Flick and Maier both used arsenicals locally to irrigate the wound. There was no benefit noted from intravenous neoarsphenamine in the present series of cases.

Smith and Manges reported 8 cases of bites of the hand in which x-ray treatment was used with uniformly good results. They gave 50 to 100 r. measured in air of 135 kv. x-ray filtered with 4 mm. of aluminum at each dose. However, as none of their patients had bone or joint involvement, the value of the x-ray therapy has not been proved.

There are 35 cases of human bites of the hand in the records of the San Francisco Hospital for the past eight years. These have been classified, after the suggestion of Welch, into early cases (before twenty-four hours), delayed cases (twenty-four hours to seven days), and late cases (seven days and later). The only amputation in the early group was performed on a patient who had had the laceration sutured immediately. There were two amputations in the delayed group and four in the late group. One patient in the late group died of bronchopneumonia following drainage of the hand.

A summary of the cases reported in the literature divided according to the elapsed time of injury before entering the hospital is given in Tables I, II, and III.

TABLE I*

EARLY CASES

AUTHOR	NO. OF CASES	AMPUTATIONS	LOST FUNCTION	DEATHS
Flick	3	1	1	
Bower	1			
Dimtza	1	1 (arm)		
Mason	2		2	
Welch	3			
Smith	4			
Maier	7			
Cohn	7	1		

*After Welch's classification.

CONCLUSIONS

1. The cases reported re-emphasize the necessity for immediate and radical treatment of human bites of the hand.

2. The prognosis of human bite infections of the hand is determined by (a) the type of organism present, (b) the time before surgery is instituted, and (3) the involvement of the tendons and joints.

3. If the patient presents himself after infection is already established, the treatment can be more conservative.

TABLE II*

DELAYED CASES

AUTHOR	NO. OF CASES	AMPUTATIONS	LOST FUNCTION	DEATHS
Flick	3	2 (hand in one)		1
Frankenthal	1	1		
Dimtza	2		1	1
Mason	5	1	3	
Welch	10	4		
Peters	1			
Hultgen	1			
Fuller	1	1		
Smith	4			
Maier	10	4		
Cohn	18	2	2	

*After Welch's classification.

TABLE III*

LATE CASES

AUTHOR	NO. OF CASES	AMPUTATIONS	LOST FUNCTION	DEATHS
Mason	6			
Welch	5	2	1	
Pilot	1	1		
Hennessey	1	1		
Cohn	10	4	2	1

*After Welch's classification.

CASE REPORTS

I. Early Cases.—

CASE 1.—D154363, D. McS. A 48-year-old police officer received a bite over the metacarpophalangeal joint of the index finger of the left hand while making an arrest. He reported immediately. A shallow laceration not penetrating the skin was cauterized. After twenty-four hours of treatment with hot wet poultices, the patient was discharged. He returned in three days, however, with a local area of cellulitis around the skin laceration. After forty-eight hours more of poulticing and splinting, the cellulitis cleared up.

CASE 2.—D100103, P. M. A man, 30 years of age, received a bite over the metacarpophalangeal joint of the middle finger of the right hand in a street fight twelve hours before entry. There was edema of the dorsum and an area of cellulitis surrounding the laceration. An x-ray showed no fracture. On splinting and hot soaks the infection cleared up in three days.

CASE 3.—D172152, B. B. A man, 36 years of age, entered with a bite over the metacarpophalangeal joint received in a street fight twenty-four hours before entry. There was edema of the dorsum and an area of cellulitis around the laceration as well as a few streaks of lymphangitis extending up the arm. Following application of heat, the infection subsided in three days.

CASE 4.—D175775, E. H. A 25-year-old man received a bite over the metacarpophalangeal joint of the middle finger of the right hand. He reported at once to a hospital where the laceration was sutured. The next morning the area about the wound was red, swollen, and tender and the entire hand was painful. On

entry, the sutures were removed and the wound explored. The tendon (extensor) and joint capsule were torn and the cartilage was cracked. The wound was débrided and packed open and soaks were started. Smears from the wound showed gram-positive cocci and filamentous bacilli. No spirochetes were found. The wound continued to drain and the extensor tendon sloughed. One month after entry the finger was amputated through the metacarpal. Four months after entry the wound had healed, but the movements of the remaining fingers were considerably impaired.

CASE 5.—D189635, W. M. A man, 25 years of age, received a bite over the metacarpophalangeal joint of the ring finger of the right hand twenty-four hours before entry. The hand was swollen and the finger tender. Pus was discharging from the ragged laceration. Smears were negative. No aerobic growth was attainable, but anaerobically a gamma streptococcus and small gram-negative coccus grew. The wound was débrided. At operation a tear in the joint capsule was noted. The joint was opened widely and the wound packed. A cast was applied. In one month the wound had healed and the motions of the hand were rapidly being restored to normal.

CASE 6.—D192323, W. L. A man, 38 years of age, received a bite on the ventral surface of the distal joint of the ring finger twenty-four hours before entry. Smears from the small laceration showed no organisms. With the application of heat, the local infection subsided in three days.

CASE 7.—D196804, H. B. A 32-year-old man received a bite over the metacarpophalangeal joint of the middle finger of the right hand twelve hours previously. On entry the hand was tender to motion. Extending from the laceration were several red streaks. There were enlarged tender glands in the axilla. Smears from the wound showed diphtheroids and staphylococci. An x-ray was negative. With the application of heat, the process subsided in four days.

II. Delayed Cases.—

CASE 8.—D172233, G. T. A man, 42 years of age, received a bite on the right hand over the fourth and fifth metacarpophalangeal joints two days before entry. The wound was cauterized by his doctor at once. The next day the hand became tender and slightly swollen. On entry the local area was red and indurated and discharged pus. Smears showed gram-positive cocci in chains and bunches. With the application of heat, the infection slowly subsided during the course of one week.

CASE 9.—D151769, E. P. A man, 41 years of age, received a bite over the knuckle of the left hand two days before entry. He cauterized the wound with iodine, but the back of the hand became swollen and tender. On entry a small ragged laceration was noted surrounded by an area of cellulitis. With the application of heat and splinting, the infection subsided in three days.

CASE 10.—D98831, L. R. A man, 20 years of age, received a bite over the metacarpophalangeal joint of the right index finger three days before entry. The next day the hand began to swell and was painful to motion. On entry a small dirty wound was noted from which nonfoul pus could be expressed. A subcutaneous abscess was drained. One intravenous injection of neoarsphenamine 0.3 gm. was given. The hand rapidly improved.

CASE 11.—D152605, J. M. A 66-year-old woman was bitten on the index finger of the right hand four days before entry. The finger became swollen and drained pus in spite of constant soaking in hot water. On entry several shallow lacera-

tions were seen on the dorsal surface of the finger from which pus could be expressed. Smears and cultures showed only hemolytic streptococci. The subcutaneous tissues were drained and the finger slowly improved after three weeks' hospitalization.

CASE 12.—D134466, T. D. A 75-year-old man was bitten on the dorsum of the right hand over the metacarpophalangeal joint of the middle finger two days before entry. The hand became swollen, hot, and tender and the finger was painful to motion. In spite of heat and rest, there was no improvement. Two weeks after entry the joint was found to be involved. The finger was amputated.

CASE 13.—D133371, G. E. A man, 31 years of age, received a bite on the right hand over the metacarpophalangeal joint of the middle finger four days before entry. Two days later, in spite of soaks, the hand became swollen and tender. On entry an area of cellulitis was seen about the laceration from which pus could be expressed. On heat and rest the hand rapidly improved.

CASE 14.—D160359, J. R. A 19-year-old boy received a bite over the metacarpophalangeal joint of the fifth finger of the right hand four days before entry. He tried soaks without benefit. On entry the dorsum of the hand was edematous and around the wound there was a grayish black necrotic zone. With the application of heat and splinting an abscess localized eleven days after entry. This was drained. The pus yielded a pure culture of hemolytic streptococci. The wound healed after two months, but no motion was present in the fifth metacarpophalangeal joint.

CASE 15.—D187618, G. LaR. A man, 43 years of age, received a bite over the metacarpophalangeal joint of the right index finger four days before entry. After two days the hand became painful and the finger was swollen and tender. On entry a shaggy laceration was seen. A smear showed gram-positive cocci but no spirochetes. The area was opened, but the joint was not involved. Neoarsphenamine, 0.3 gm., was given. On rest and soaks the infection rapidly subsided.

CASE 16.—D185772, J. S., a man, 36 years of age, received a bite over the first metacarpophalangeal joint of the right hand three days before entry. The day before entry the hand became painful and red streaks were seen. On entry a small dirty laceration was noted from which streaks of lymphangitis extended up the arm. Smears from the ulcer showed gram-positive cocci but no fusiform bacilli or spirochetes. On heat and rest the inflammation subsided in one week.

CASE 17.—D170986, J. V. A man, 32 years of age, received a bite on the lower third of the forearm four days before entry. On entry a dirty shallow ulcer about 2 cm. in diameter was noted on the dorsum of the forearm just above the wrist. From the ulcer there were several streaks of lymphangitis extending up the arm. The area was excised with the cautery. After two attempts a graft took and the wound healed.

CASE 18.—D157229, W. K. A man, 23 years of age, received a bite over the metacarpophalangeal joint of the fourth finger of the right hand two days before entry. He used soaks at once but the hand became more swollen and painful. On entry a ragged wound was seen surrounded by an area of cellulitis. An x-ray showed thinning of the joint cartilage. Two days after entry the wound was opened and the capsule found to be torn. It was opened widely and packed. One month after entry the hand was said to be "healing."

CASE 19.—D188783, O. B. A man, 35 years of age, received a bite over the proximal joint of the index finger of the left hand two days before entry. He received emergency treatment. The finger soon became painful to motion and swollen. On entry a small laceration was seen from which thin pus drained.

Smears showed no organisms but both hemolytic streptococci and staphylococci were present on culture. When the wound was drained, the joint was seen to be intact. The infection rapidly cleared following drainage.

CASE 20.—D183973, L. P. A man, 48 years of age, received a bite over the distal joint of the index finger of the left hand three days before entry. The finger became swollen and painful to motion. On entry the entire finger was swollen and painful. Tenderness was present over the course of the tendon sheath. A smear from the wounds showed spirochetes, fusiform bacilli, and gram-positive cocci. Cultures showed "mouth organisms." The patient was given 0.45 gm. neoarsphenamine intravenously. The tendon sheath was opened and the tendon found to be necrotic and sloughing. Five days later the finger was disarticulated at the metacarpophalangeal joint. An x-ray taken at this time showed osteomyelitis of the head of the metacarpal. Small sequestra continued to discharge. Healing did not take place for five months.

CASE 21.—D210553, S. R., a man, 42 years of age, received a bite over the metacarpophalangeal joint of the right index finger six days before entry. Two days later the hand became swollen, tender, and painful to motion. On entry the hand was brawny, red, and indurated about the laceration. An x-ray showed no fracture. On heat and rest the inflammation rapidly subsided. During the course of treatment, sulphanilamide and x-ray therapy, 150 r. through a 25 by 15 field were also given.

CASE 22.—D191133, C. A. A 25-year-old man received a bite over the metacarpophalangeal joint of the right fifth finger three days before entry. Examination showed a diffusely swollen hand with an area of cellulitis about the laceration. There were enlarged tender glands in the axilla but no lymphangitis. An x-ray showed no fracture. The patient signed his release the next day.

CASE 23.—D194513, H. P. A man, 27 years of age, received a bite over the metacarpophalangeal joint of the thumb of the left hand five days before entry. Two days before entry the hand became swollen and painful. Examination showed a ragged laceration surrounded by an area of cellulitis. A Wassermann test was positive, but the patient had an old history of syphilis for which he had been receiving treatment. The wound was opened and the joint capsule was found to be intact. On heat and rest the infection rapidly subsided.

CASE 24.—C. A. A man, 26 years of age, received a laceration over the metacarpophalangeal joint of the right fourth finger four days before entry. The day before entry the hand became swollen and painful to motion. On entry a local area of cellulitis was seen about the laceration. On heat and rest the infection rapidly subsided.

CASE 25.—D210580, G. S. A woman, 42 years of age, received a bite on the right thumb two days before entry. The next day the thumb became swollen and painful. The pain extended up the arm to the axilla. The patient felt feverish. Examination showed a ragged laceration on the dorsum of the thumb from which pus was draining. Smears showed staphylococci and streptococci. After five days of heat and rest an abscess localized. An incision was made on the dorsum of the thumb and extended up to the wrist. The joint capsule was not involved. An x-ray of the hand was negative. When seen two months later, the tendon of the extensor pollicis longus was sloughing.

III. Late Cases.—

CASE 26.—D127434, M. M. A man, 49 years of age, received a bite over the right index finger seventy-five days before entry. He had been treated by soaks and intravenous neoarsphenamine. The finger continued to drain and a small ab-

scess was opened. There was no improvement. On entry the entire finger was brawny, swollen, stiff, and tender. Pus was discharging from a wound on the dorsum of the finger. An x-ray showed osteomyelitis in the phalanges of the finger as well as demineralization of the entire hand. Three months after the original injury the finger was amputated. The stump was slowly healing over.

CASE 27.—D176087, J. S. A man, 35 years of age, received a bite over the first metacarpophalangeal joint of the right hand ten days before entry. He reported at once to a hospital where the laceration was sutured. Three days before entry the wound broke down and discharged pus. The hand was painful and swollen. On entry there were several streaks of lymphangitis extending up the arm. An x-ray of the hand showed no osteomyelitis. Following poulticing and regression of the lymphangitis, the wound was opened and drained. The joint capsule was not damaged. Healing took place rapidly.

CASE 28.—D161898, J. R. A man, 29 years of age, received a bite on the right fifth finger while confined in jail twenty days before entry. He consulted a doctor two days later and was advised to soak the hand in hot water. The finger became more swollen and tender. On examination the original wound was noted over the distal joint. The entire finger was swollen, red, and tender. The distal joint was disarticulated. When seen two months later, the third, fourth, and fifth fingers of the right hand were stiff and there was limitation of motion at the wrist joint. Physiotherapy was instituted.

CASE 29.—D157239, F. N. A man, 36 years of age, received a bite over the metacarpophalangeal joint of the index finger of the right hand seven days before entry. The laceration was sutured at once at another hospital. The next day the hand started to swell and become painful to motion. Three days before entry the sutures were removed and the wound discharged pus. On entry the hand was swollen and the right index finger painful to motion. Foul pus was draining from the wound. Smears of the pus showed spirochetes and fusiform bacilli. The wound was opened and drained and the joint capsule found to be torn. The patient was given heat and rest as well as two intravenous injections of neoarsphenamine. A second drainage was performed without improvement. One month after entry the finger was amputated. The stump healed over in three weeks' time.

CASE 30.—D164309, H. R. A 22-year-old man received a bite on the left fifth finger seven days before entry. He was treated at once in a hospital. Two days later the wound began to drain foul pus. Then the hand became swollen. On examination a foul dirty wound was seen on the dorsum of the finger. Smears showed spirochetes and fusiform bacilli. An x-ray showed osteomyelitis of the second phalanx. He was given one injection of neoarsphenamine. Two weeks after entry the distal two phalanges were disarticulated. Healing took place slowly.

CASE 31.—D144083, O. S. A man, 45 years of age, received a bite on the left fourth finger fourteen days before entry. He neglected to treat it in any manner. On entry there was limitation of motion of the hand with a wound on the dorsum of the fourth finger from which pus could be expressed. Smears showed streptococci, staphylococci, and small bacilli. An x-ray showed osteomyelitis with destruction of the joint of the terminal phalanx. Drainage was instituted and the small bones allowed to sequestrate themselves.

CASE 32.—D188953, J. L. A man, 32 years of age, received a bite over the metacarpophalangeal joint of the fourth finger of the left hand thirty days before entry. He was treated elsewhere. After one week the inflammation seemed to subside. Seven days before entry the site of injury became swollen and tender, gradually increasing in extent. He had an old history of asthma and bronchitis.

On entry an area of cellulitis was seen about the laceration which was again discharging. An x-ray showed no osteomyelitis or fracture. With gas oxygen ether anesthesia the wound was drained. The tendon was found to be frayed, but the joint capsule was intact. Following operation the patient developed bronchopneumonia from which he died.

CASE 33.—D189719, O. St. J. A man, 29 years of age, received a bite over the index and middle fingers and the third metacarpophalangeal joint of the right hand nine days before entry. Five days before entry the skin overlying the areas became black and necrotic. Two days before entry he noted red streaks extending up the arm. Examination showed shallow superficial ulcers at the sites of injury from which a well-marked lymphangitis extended. On heat and rest the infection rapidly subsided.

CASE 34.—D141428, F. M. A man, 22 years of age, received a bite over the metacarpophalangeal joint of the right middle finger fourteen days before entry. The hand did not become painful until three days before entry. On examination a crusted superficial lesion was seen surrounded by an area of induration from which several streaks of lymphangitis extended up the arm. Smears from the lesion showed only gram-positive cocci in chains. On heat and rest a superficial abscess localized. Following drainage the infection rapidly subsided.

CASE 35.—D180760, E. B. A man, 49 years of age, received a bite over the ventral surface of the fourth finger of the right hand eight days before entry. The finger became discolored and swollen. An x-ray showed osteomyelitis and suppurative arthritis of the proximal interphalangeal joint. The wound was drained. When seen four months later, the right fourth and fifth fingers had developed a flexion contracture.

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PNEUMOCOCCIC PERITONITIS

Its Present Status

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PATHOGENESIS

THERE is much difference of opinion regarding the avenue by which the pneumococci may reach the peritoneum. Obadalek[1] believes that the bacteria are swallowed and that they migrate through the intestinal wall in the region of the ileocecal valve because of stasis in this area. He does not believe that the genital tract can be a site of invasion unless the feces contaminate the vagina. Koennecke[2] also believes that the bacteria are swallowed, but that they enter the peritoneal cavity only by contamination of the genital tract by fecal material. Jensen,[3] Wolfsohn,[4] and McCartney and Fraser[5] fed pneumococcus cultures to mice; none were able to produce peritonitis, but Jensen found bacteria in the walls of the intestines.

Rischbieth[6] advances the view that pneumococcic peritonitis is always secondary to septicemia. Blake and Cecil[7] were unable to produce pneumonia or peritonitis by intravenous injection of pneumococci; the animals died from the bacteremia. Jensen,[3] and McCartney and Fraser[5] showed that pneumococci reached the blood stream in a rabbit a few minutes after intraperitoneal injection. Rolleston[8] found eleven cases of peritonitis in 4,454 cases of pneumonia; Rischbieth[6] found one case in 6,000 cases of pneumonia; Elkin[9] reports three in 1,908 cases. Peiser[10] believes that the uninjured peritoneum is impermeable to the invasion of organisms from the blood stream.

McCartney and Fraser[5] refute the hematogenous and enterogenous avenues of infection; they believe that primary pneumococcic peritonitis occurs only in females and that the genital tract is always the portal of entry; it follows that all cases in males are of the secondary type.

DIAGNOSIS

This disease has a predilection for children up to the age of 14 years; females predominate in a ratio of about 5:1. The onset is acute; only rarely is there a prodromal period of one or two days during which the patient complains of general malaise, cough, or gastrointestinal upset. The disease usually begins suddenly with nausea, emesis, and severe abdominal pains; the temperature is high. Constipation is the exception and diarrhea the rule; the latter can be considered almost

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pathognomonic. There is frequency of urination. The general condition is fairly good at the onset; this is remarkable since the mortality is very high at this stage, but this can probably be explained by the absence of the facies abdominalis which one is accustomed to see in severe cases of peritonitis.

Cyanosis of the face is frequently seen and there is often herpes labialis. The pulse is usually good in the early stages of the disease. The early diagnosis of peritonitis is obvious; there is tenderness of the entire abdomen with muscular rigidity; however, the rigidity is not as pronounced as in other forms of peritonitis and may be described as having a doughy consistency. The leucocyte count is usually high, although this is not a constant finding; the count frequently reaches 30,000 to 40,000 leucocytes per cubic millimeter of blood; the polymorphonuclear leucocytes usually comprise 80 to 90 per cent of the total. A positive blood culture is obtained soon after the onset and it tends to remain positive until all exudate has been evacuated from the peritoneal cavity; the organisms in the blood stream and the peritoneal cavity are always of the same type. Pneumococci of the same type can also be recovered from the spinal fluid. Bronchitis and pneumonia are frequent early complications. The acute phase usually ends in death a few days after the onset; however, the patient may be sufficiently fortunate to enter the subacute and subsequently the chronic stages of the disease. During the subacute phase, the temperature falls and the patient appears to be better; the diarrhea and emesis cease and the abdominal tenderness diminishes. In about four days the chronic phase is reached; the temperature rises and the abdominal circumference increases; abdominal palpation discloses fluctuation and fluid wave. An abscess can be outlined; this abscess sometimes reaches considerable size and may lead to cachexia and death or may perforate through the abdominal wall, usually at the umbilicus. Metastatic abscesses may develop in bones and joints; pneumococci can be recovered from these foci.

The condition most often confused with pneumococcic peritonitis is acute suppurative appendicitis with or without perforation; the confusion is increased by the fact that the pain in the former often begins in the right lower abdominal quadrant. However, there are a few points which make the differentiation fairly simple. The leucocyte count is usually three or four times greater and the fever is earlier and higher in pneumococcic peritonitis. The pain, tenderness, and rigidity are more diffuse in pneumococcic peritonitis. Diarrhea is seen in practically every case of pneumococcic peritonitis while constipation is the rule in appendicitis. A final complete differentiation can be made by abdominal puncture with a lumbar puncture needle. Neuhof and Cohen[11] made one hundred peritoneal punctures to determine the causative organism in peritonitis; they were able to isolate

the organism in every case and in no instance was there puncture of the intestines. In most females pneumococci can be found in the cervical exudate even before the peritonitis develops.

PATHOLOGY

Pneumococcic peritonitis is commonly divided into primary and secondary types, but this is a differentiation for convenience only; the term primary means merely that the origin of the infection is not known, while in secondary cases there is a known previous focus of infection. Actually, all so-called primary cases occur in females and are secondary to pneumococcic cervicitis and endocervicitis. Michant,[12] in 1901, was the first to suggest this classification and it has since been followed without outspoken question. Many authors divide the pathology into diffuse and localized types as though they were entirely different varieties of the disease; this is incorrect because the process is always diffuse in the acute and subacute stages and always becomes localized in the chronic phase. About 40 per cent of all pneumococcic peritonitis occur as complications of nephrosis; however, pneumococci and streptococci are about equally divided in the etiology of nephrotic peritonitis. In nephrosis there is a low colloidal osmotic pressure of the blood which causes an abnormal tendency toward filtration of plasma from the blood stream into the peritoneal cavity. This ascitic fluid offers an excellent culture medium for both pneumococci and streptococci.

In the acute stage of the disease there are peritoneal hyperemia and edema with the production of a layer of fibrin over all serosal surfaces; mesenteric lymphadenitis is commonly observed. In females there are usually hyperemia and edema of the oviducts. The peritoneal cavity contains a serous exudate in the acute phase, which lasts only about seventy-two hours, at the end of which time the subacute stage is reached; this period usually lasts for about four days. During this stage the exudate becomes purulent and the peritoneum makes an attempt at localization; the exudate contains large flakes of fibrin which cause the formation of multiple adhesions and subsequently one or more abscesses. When the abscess formation or localization process becomes complete it may be said the chronic stage has been reached. These abscesses may perforate spontaneously through the abdominal wall at the umbilicus or into the rectum. The bacteria usually enter the blood stream in the acute phase and may be deposited in various parts of the body, producing pneumonia, bronchitis, pericarditis, pleuritis, arthritis, or otitis media.

TREATMENT

Here, as in many other diseases, good treatment depends upon good diagnosis. Most of the recorded deaths have occurred in cases that were erroneously diagnosed as acute surgical emergencies and oper-

ated upon. The appallingly high mortality rate in this disease could be materially lowered by correct early diagnosis and expectant treatment until several days after the infection has become completely localized. Operation should never be performed until one or more definitely localized collections of exudate can be positively elicited. Diagnosis can be made immediately by peritoneal puncture and cervical smear. There is sufficient sound and intelligent treatment necessary during the waiting period to keep the physician occupied.

The carbon-dioxide combining power of the blood should be determined and oxygen administered if anoxemia is present. Sufficient exudate should be obtained from the cervix by applicator and from the peritoneal cavity by puncture to prepare cultures; the blood should also be cultured. The pneumococcus should be typed and sufficient antipneumococcic serum immediately administered; 20,000 units should be given intravenously every four hours during the first twenty-four hours; during the second twenty-four hours 20,000 units should be given intramuscularly every four hours. A total of 240,000 units should be given; serotherapy probably has little effect upon the actual peritonitis, but it decreases the possibility of complications, more particularly pneumonia.

Paralytic ileus may be controlled by an indwelling duodenal tube with continuous suction and by lumbar anesthesia; 250 c.c. of blood should be administered every forty-eight hours. Forty-eight gr. (3.2 gm.) of sulfanilamide in 400 c.c. of isotonic saline solution may be given every twelve hours; if given intravenously, the drug is eliminated by the kidneys before any benefit can be derived. The efficacy of sulfanilamide in pneumococcic peritonitis is still open to debate. The diarrhea can be successfully controlled by the use of any of the commercial kaolin preparations either by mouth or by retention enemas. The patient should be allowed no food or water by mouth; the fluid balance should be maintained by the use of glucose, saline, or Hartmann's solution by the intravenous route.

The treatment that definitely saved the life of the patient herein reported is that described by Crocker, Valentine, and Brody,[13] the use of controlled nonspecific immunotransfusions. A donor is given fifty million killed typhoid bacilli intravenously; if there is no reaction within one hour, twenty-five million additional bacteria are administered. A maximum reaction is reached in about eight hours, at which time the donor's temperature may be from 104° to 105° F. and his blood may contain from 25,000 to 30,000 leucocytes per cubic millimeter. At the peak of the reaction, the patient is given 250 to 300 c.c. of this blood by transfusion. After employing this treatment on a number of cases of bacteremia, I have concluded that one hundred million bacteria should be given at the first injection and that 350 to 400 c.c. of blood should be transfused.

When localization is definitely complete, drainage should be obtained; if the patient is a female and fluctuation can be elicited in the posterior fornix by vaginal examination, very safe and efficient drainage may be secured by posterior colpotomy. In all other cases a small incision should be made over the site of maximum fluctuation; incision should be made under local anesthesia when possible; if inhalation anesthesia is employed, it should be a light type, preferably nitrous oxide. From one to three Penrose drains should be inserted through the incision and left in situ until a satisfactory sinus tract has been established; this may require from two to seven days.

The patient should be closely observed for several weeks after recovery appears to be complete as sequelae are often delayed and peritoneal abscesses sometimes recur after drainage has ceased.

STATISTICAL DATA

Salzer[14] reports 31 cases with a mortality rate of 40 per cent; of 8 cases operated upon during the acute stage, 6 died; he made an early diagnosis in 21 cases and treated them conservatively; 15 of these cases recovered. He emphasizes the importance of making a cervical smear to facilitate early diagnosis. Mathieu and Davioud[15] report 12 cases, all of which were females; each case had diarrhea and was preceded by sore throat. They advise expectant treatment with drainage late, if at all. McCartney and Fraser[5] report 56 cases, 44 per cent of which were females; their mortality rate was 42 per cent; in 11 of the 12 males pneumonia was the primary source of infection. In their investigation they found that the bacteria could not migrate through the intestinal wall. They feel that the bacteria enter the vagina and reach the peritoneal cavity by way of the uterus and oviducts.

Lipschutz and Lowenberg[16] report 13 cases with a mortality rate of 100 per cent; 80 per cent of their cases were operated upon; 90 per cent began with a sore throat; 12 of the 13 cases were females. They found pneumococci in 3 vaginal smears and blood cultures were positive in 9 instances. They believe that the genital tract is the portal of entry; they found a maximum amount of involvement in the right lower abdominal quadrant; therefore, they advise incision and drainage in this area.

Cole[17] reports 26 cases covering an eighteen-year period at St. Louis Children's Hospital; there were 14 deaths with a mortality rate of 54 per cent. There were 10 cases of nephrosis, of which 7 died, giving a corrected mortality rate, exclusive of this group, of 44 per cent. Contrary to the general belief that patients with pneumococcic peritonitis belong to the lower strata of society, Cole found that all of his patients had the advantage of average living conditions. Of the 16 nonnephrotics, 7 were presumably secondary to upper respiratory infections; 9 cases demonstrated no primary lesion. Five patients were

operated upon during the chronic stage; all of these patients survived. Only 1 vaginal culture was obtained; it revealed pneumococci of the same type as those found in the peritoneal cavity. Perforation of the abdominal wall at the umbilicus occurred in 20 per cent of all cases exclusive of the nephrosis group. Pneumonia and empyema were the most common complications and were very important contributory factors toward death.

Horine[18] reports 7 cases, 4 of which died, giving a mortality rate of 57 per cent; 5 cases demonstrated definite primary lesions, while 2 revealed none. There were 5 females and 2 males. The only fatal cases were those operated upon during the first week of the disease; all cases operated upon during the chronic stage recovered. Horine believes, and rightfully so, that operative intervention prior to definite localization will lead only to disaster and a continued high mortality rate in this disease. Another advocate of late surgery is Ciminata,[19] who reports 8 cases, none of which revealed a primary focus; his mortality rate was 50 per cent. Two patients were operated upon during the acute stage and 2 during the subacute phase; all 4 of these patients died; 4 patients were operated upon during the chronic stage and all recovered.

MacLeod and Farr[20] report 6 cases, all of which were complications of nephrosis; 4 patients died, giving a mortality rate of 66 per cent; the ages were from 2 to 7 years; there were 5 males and 1 female. They found pneumococci of the same type both in the throat and in the peritoneal cavity in all cases. They had been making periodic throat smears on a group of 12 children with nephrosis; 3 of the children who developed pneumococcic peritonitis revealed pneumococci in throat culture before the onset of the peritonitis; in the 3 other cases the throat culture became positive soon after the onset of the peritonitis.

Johnston[21] reports 5 cases, all of which died; the ages varied from 4 to 53 years; there were 3 females, 1 male, and the sex was not stated in the fifth case. Four patients were operated upon during the acute stage and 1 during the chronic phase; the latter patient was operated upon a second time two weeks after the first operation because of the formation of a new abscess; at autopsy an acute process was found at the base of the left lung. This group further strengthens the argument in favor of late surgery.

Bass[22] reports 19 cases covering a twelve-year period at Mount Sinai Hospital; there were 11 deaths, giving a mortality rate of 58 per cent; all cases were females from 16 months to 10 years of age. His mortality rate is exactly the same as that of Schonenberger[23] computed on 376 cases, 214 of which died. Bass reports that 12 of his patients were operated upon and of these 7 recovered; 1 patient underwent spontaneous perforation with recovery. Six patients were not operated upon; all of these died. Blood cultures were secured in 12 cases

and 4 were positive; vaginal cultures were positive in 7 cases. Only 1 patient operated upon in the acute stage recovered; all other patients operated upon in this phase died. Bass emphasizes the importance of vaginal smears and peritoneal punctures as means of making an early diagnosis; he believes that specific antiserum should be given as soon as the type of organism is determined.

Fricke[24] reports 10 cases covering a five-year period at the Lenox Hill Hospital; 8 were children and there were 2 adults. Of the 8 children, 7 were females; and both of the adults were females. Six of the children died and both of the adults recovered, giving a mortality rate of 60 per cent. Six of the children gave a past history of pertussis, an element which Fricke believes to be significant. One of the adults had postabortion peritonitis and was treated with specific serum without operation; the other adult was operated upon.

King[25] is an advocate of posterior colpotomy; he reports 3 cases in adult females ranging from 36 to 46 years of age; all 3 cases recovered. He performed posterior colpotomy in 2 cases, but in the third case no exudate was obtained and it was necessary to make an abdominal incision; laparotomy revealed a well-localized abscess involving the right oviduct, ovary, appendix, and cecum. King believes that most cases in females have their origin in the vagina; he further believes that this disease is much more common in adult females than the literature would indicate.

Glazier, Goldberg, and Weinstein[26] report 1 case in a 5-year-old female child who recovered without operation; specific antipneumococcic serum was given credit for the recovery. Diagnosis was based only upon positive blood culture and physical signs of peritonitis.

Hymanson[27] reports an unusual case in a male child 10 weeks of age; there were definite signs of meningitis but no indications of abdominal disease. The child died and autopsy revealed pneumococcic peritonitis and right interstitial pneumonia; the brain and meninges were normal.

Hayden and Dunphy[28] report a case in a female child 6 years of age; on the third day of illness she was operated upon and she died on the sixth postoperative day. These men emphasize the importance of vaginal smears and peritoneal punctures to facilitate early diagnosis.

Sager and Raffel[29] report a case in a 3-year-old colored female; on the second day of illness she was operated upon; because only a small amount of exudate was observed, the wound was closed without drainage. The cultured exudate from the abdomen revealed pneumococci. The chief postoperative treatment was the administration of large doses of prontylin by mouth; the authors believe that the patient's ultimate recovery was due to the prontylin.

Gibson[30] reports 8 cases which were studied only from the standpoint of leucocytosis; he found that the leucocytes varied from 10,000

to 50,000 per cubic millimeter of blood and that the polymorphonuclear leucocytes represented 87 to 97 per cent of the total count. He believes that both the leucocyte count and polymorphonuclear percentage are sufficiently high in pneumococcic peritonitis to be diagnostic. He reports control cases to illustrate the difference between pneumococcic and other forms of peritonitis.

TYPICAL CASE REPORT

The patient, a white, unmarried, female stenographer, 18 years of age, was admitted to St. Paul's Hospital by ambulance on May 16. Her chief complaint was severe cramping pain in the lower abdomen. From May 8 to May 13 she had experienced a menstrual period which was normal in amount, duration, and cycle. Twenty-four hours after menstruation ceased, bleeding was resumed; the hemorrhage was profuse and many clots were passed. This bleeding was accompanied by increasingly severe lower abdominal pain; there was nausea but no emesis. There had been a moderately profuse vaginal discharge for three days previous to the onset of the last menstruation; there had been no previous vaginal discharge and all previous menstrual periods had been normal in amount, duration, and frequency. There were no other symptoms associated with the present illness and the past history was irrelevant.

Examination revealed a well-developed and well-nourished patient lying quietly in bed; she displayed an anxious facies and was obviously acutely ill. The sublingual temperature was 103.4° F. and the pulse rate was 126 beats per minute. The blood pressure was 104 systolic and 62 diastolic. Systems above the diaphragm failed to reveal any evidence of pathology. The abdomen revealed a boardlike rigidity, which was graded four, and diffuse tenderness, graded four; distention was graded only one. Because of the extreme rigidity, no viscera were palpable. Vaginal examination revealed total absence of the hymen; the cervix was soft and semipatulous. Abdominal rigidity prevented adequate bimanual examination. The vagina exuded a dark, serosanguineous fluid, a specimen of which was collected for smear and culture. The smear revealed a predominance of gram-positive lancet-shaped diplococci and the culture produced a pure strain of Type V pneumococcus. Blood count on admission revealed 10.5 gm. of hemoglobin per cubic centimeter; there were 4,040,000 erythrocytes and 7,040 leucocytes per cubic millimeter; 92 per cent of the total leucocytes were polymorphonuclear cells. The color index was 0.9 and the nuclear index was 3.6. A catheterized urine specimen showed albumin, graded one; microscopic examination displayed pus cells, graded one; finely granular casts, graded four; and hyaline casts, graded one. The sedimentation rate was 117 mm. at the end of one hour; the erythrocytic volume pack was 37 c.c. per 100 c.c. of blood. The blood Wassermann, Kline, and Eagle tests were negative.

When the vaginal smear displayed bacteria having the morphology of the pneumococcus, it was decided to assume that the patient was suffering from pneumoccocic peritonitis; without waiting for the results of the culture, treatment was begun accordingly. Because of the excessively high mortality rate in early surgery on this type of case, it was quickly decided to postpone abdominal drainage until it was positive that localization was complete. However, while awaiting this localization, the patient was rapidly becoming moribund; therefore, rather heroic treatment was begun while awaiting results on cultures of blood and vaginal exudate.

A Levin type duodenal tube was introduced and continuous suction established; 1 L. of 5 per cent glucose in isotonic saline solution was given intravenously every eight hours. Forty-eight gr. (3.2 gm.) of prontylin in 400 c.c. of isotonic saline solution was given subcutaneously every twelve hours. Twenty-four hours after admission, a type V pneumococcus was found in cultures from both the blood and

the vaginal exudate. The patient was immediately given 20,000 units of Type V antipneumococcic serum intravenously; this injection was repeated every four hours until 120,000 units had been administered. During the next twenty-four hours, 20,000 units were given intramuscularly every four hours until an additional 120,000 units had been given.

Fifty-two hours after admission, the patient developed dyspnea, cyanosis, and coarse crepitant râles over the entire chest; there was a sudden rise in sublingual temperature from 102.6 to 105° F. and the pulse rate became elevated from 126 beats per minute to 154 beats. A bedside chest roentgenogram revealed bilateral diffuse bronchopneumonia; the patient soon developed a cough which produced a mucosanguineous sputum; this sputum was found to contain Type V pneumococci. Immediately after the onset of pneumonia, serotherapy was resumed to the extent of 120,000 units over a twenty-four-hour period; the patient was also given two high frequency radiations of the chest each day. Because of the large amount of fluid in the alveoli, the volume fluid intake was diminished by substituting 50 c.c. of 50 per cent glucose for the liter of 5 per cent solution. Transfusions of 300 c.c. of whole blood were given every other day.

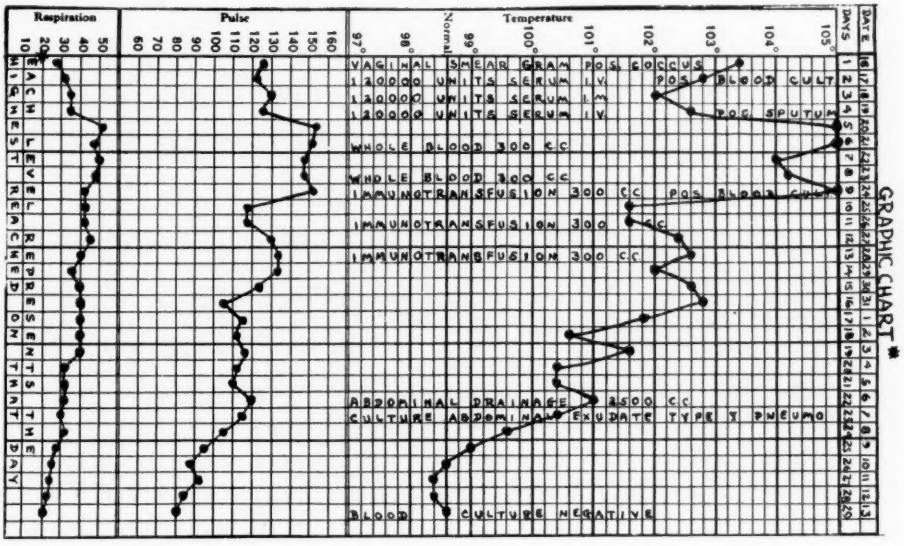

Fig. 1.

The right lung responded well to treatment, but five days after the onset of pneumonia the left lung developed distant breath sounds and a flat percussion note; a roentgenogram displayed left pleural effusion and patchy pneumonitis of the left lung; the right lung revealed no pathology. At this time the blood culture again showed Type V pneumococcus and the carbon-dioxide-combining power of the blood was 58 volumes per cent. On this day the patient became moribund and it became evident that more drastic treatment was necessary if death was to be averted. Several cases of bacteremia had previously been saved by use of the controlled non-specific immunotransfusions of Crocker, Valentine, and Brody[13] so it was decided to attempt this form of treatment. A suitable donor was given one hundred million killed typhoid bacilli intravenously and fifty million were injected one hour later. At the end of seven hours his sublingual temperature was 104.2° F. and his blood revealed 40,000 leucocytes per cubic millimeter; at this time 300 c.c. of blood was withdrawn and injected into the patient. Within twenty-four hours there was a dramatic response and the patient roused from her moribund state; two more of

these immunotransfusions were given at forty-eight-hour intervals. Following these transfusions, the patient made a very spectacular improvement. On June 6, three weeks after admission, the abdomen was distended to grade four and had a consistence sometimes described as doughy; there was no longer any frank rigidity present. It was felt that the exudate was well localized so a 1 inch (2.5 cm.) incision was made in the midline just below the umbilicus; 2,500 c.c. of thick purulent exudate was withdrawn and two Penrose drains were inserted. The peritoneal exudate produced a pure culture of Type V pneumococcus.

On June 13 the patient's condition was good; the temperature and pulse were normal, and the abdominal incision was draining well. Roentgenogram of the chest revealed only a small amount of fluid at the left base; the blood culture was negative for the first time. The patient was returned to her home on this date under close observation.

On July 14, approximately two months after onset, the sublingual temperature was 101.6° F. and the pulse rate was 132 beats per minute; the abdomen was scaphoid and displayed no tenderness, rigidity, fluctuation, or masses. The entire left chest revealed a flat percussion note and absence of breath sounds; the mediastinal contents were displaced to the right. The left pleural cavity was aspirated and 640 c.c. of thick purulent exudate was withdrawn. A No. 18 catheter was placed in the pleural cavity through the space between the sixth and seventh ribs in the postaxillary line and sutured in place. This pleural exudate produced a pure culture of Type V pneumococcus. The chest drained during the following five weeks, after which time the patient made an uneventful recovery; she has consistently gained weight and has enjoyed excellent health since her illness.

SUMMARY

The present status of pneumococcic peritonitis has been reviewed and a typical case presented; this case was carefully followed both from a clinical and a laboratory point of view. The Type V pneumococcus was first found in the vaginal exudate during the existence of an acute generalized peritonitis; these organisms were then found in the sputum, blood, and later in the abdominal and pleural exudates.

There has been employed a new treatment, the use of which has never before been reported in pneumococcic peritonitis. It is earnestly and profoundly felt that this treatment, controlled nonspecific immunotransfusions, was solely responsible for the recovery of this patient; she not only failed to improve under prontylin and specific serotherapy but actually became worse during their use.

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ENZYME STUDIES IN EDEMA OF THE PANCREAS AND ACUTE PANCREATITIS

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THE clinical picture of edema of the pancreas was observed first by Archibald[1] and described as clinical entity by Zoepffel.[2] Some observers believe that edema of the pancreas is an inflammatory process, associated usually with infections of the biliary system, while others see in it a precursor of pancreatic necrosis; in other words, the diverging opinions represent the concept of inflammation with or without infection versus the concept of fermentative changes.

Archibald believes that edema of the pancreas represents an inflammatory but not an infectious process, like an aseptic inflammation following injection of croton oil.[3]

Edema of the pancreas can easily be produced in animals. A few minutes after the injection of bile or some other substances into the pancreatic duct an interstitial edema appears which spreads very quickly over the pancreatic gland and reaches its maximum in fifteen to thirty minutes after injection. This amazingly fast spreading of the process is hardly compatible with the assumption of an inflammatory basis. The question rather arises whether we may not be dealing with a diffusion of pancreatic juice in consequence of intrapancreatic activation of enzymes.

Mann and Giordano[4] and Rich and Duff[5] believe that injections into the pancreatic duct rupture ductules and acini, thereby permitting pancreatic juice to diffuse into the interstitial tissue of the gland and to produce inflammation. We have met their objections and believe we have disproved them.

The following experiments were performed to study this problem: Pancreatic edema was produced in a series of dogs by injection of gallbladder bile, liver bile, or olive oil in amounts of 0.1 to 3 c.c. into the main pancreatic duct and subsequent ligation of the duct. In each case a marked interstitial and subcapsular edema of the pancreatic gland appeared rapidly. About fifteen minutes after injection, a few drops of subcapsular fluid were aspirated after the capsule had been perforated very carefully, avoiding injury to the gland itself.

The analysis of the aspirated fluid revealed in each case a considerable amount of amylase and of lipase. Trypsin was estimated in one instance only and was found to be present.

One hour after injection of the pancreatic duct, a bloody fluid was found in the abdominal cavity of these dogs, which increased in amount

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TABLE I

EXPERIMENTS ON DOGS*

EXPERIMENT NO.	WEIGHT IN KG.	MATERIAL INJECTED C.C.	DEGREE OF PANCREAS EDEMA	TIME IN HR.	ENZYME CONCENTRATIONS IN					
					EDEMA FLUID		PERITONEAL FLUID		BLOOD SERUM	
					AMYLASE	LIPASE	AMYLASE	LIPASE	AMYLASE	LIPASE
1	7.5	0.1 gbb.†	++	¼	8,000					
2	20.0	0.1 gbb.	+++	Control					32	
				¼	2,500					
				1			320		64	
				2			640		64	
3	22.5	0.1 gbb.	+	¼	800					
4	18	1.5 gbb.	++	¼	750	0.99‡				
5§	10	1.5 gbb.	+	¼	50,000					
6	10.5	1.5 olive oil	+	¼	256	1.2				
7	12	1.5 liver bile	++	Control					64	
				¼	4,000	0.8				
				1			2,000	3.0	64	
				2			2,000	1.5	64	
8	20.0	3 liver bile	+++	Control					64	0.5
				1			512	2.2	64	
				2			2,000		256	
				3			6,000	2.4	256	1.0
				4			1,000	2.2	256	1.2
				5			+1,000	2.4	512	1.45

*Amylase was estimated by the Wohlgemuth method;[6] lipase by the Crandall and Cherry method;[7] and trypsin by Anson and Mirsky method.[8] The ferment concentration is expressed: amylase in Wohlgemuth units ($d\ \frac{38}{30}$); lipase in c.c. n/20 Na OH; and trypsin in mg. tyrosin.

†Gall-bladder bile.

‡Trypsin, 0.08.

§Pancreatic secretion stimulated by secretin.

as time progressed. The appearance of this exudate was noted in experiments in which the capsule of the pancreas was not incised, as well as in experiments in which it had been perforated for aspiration of subcapsular edema fluid. An analysis of this exudate was performed in three cases and revealed the presence of high concentrations of amylase and lipase (Table I). These enzymes of the peritoneal fluid might be derived directly from the pancreas due to further diffusion of pancreatic juice or they might be due to an increased concentration of enzymes in the exuding blood and serum.

Serum amylase was determined in Experiments 2, 7, and 8; no remarkable changes were noted within two hours in Experiments 2 and 7. In Experiment 8 serum amylase and lipase were followed over five hours and both showed distinct increases, due evidently to gradually increasing pathologic changes of the pancreas which could be observed in the course of the experiment. However, the rise of amylase and lipase values in the blood did not reach by far the enzyme concentrations found in the exudate and began after two hours, while the rise in the exudate became apparent after one hour. This shows that the enzyme contents of the peritoneal fluid could hardly be derived from the blood, but originated from the pancreas itself.

Artificially produced edema of the pancreas in dogs offers very much the same pathologic picture as in man. It seems reasonable therefore to assume that in man also pancreatic edema may be produced by intrapancreatic activation and consequent diffusion of pancreatic juice and that, as in the dog, the edema fluid will contain pancreatic enzymes. This has not been investigated as yet.

Since edema as well as necrosis of the pancreas seems to develop as a consequence of intrapancreatic activation of pancreatic enzymes, we may assume that in both instances a diffusion of pancreatic juice into the peritoneal cavity may occur. I have been able to prove this in operative cases of pancreatic disease in man.

A high concentration of amylase was found in the peritoneal fluid of each of nine cases I operated upon. Two of them had edema of the pancreas, four had acute pancreatitis with fat necrosis, and three had a hemorrhagic necrosis of the pancreas.

DISCUSSION

We believe that such small amounts of fluid as 0.1 c.c., i.e. 2 drops, cannot possibly rupture ductules or acini. Rich and Duff used amounts of 3 to 10 c.c. of fluid, amounts which seem so large that we agree that physical damage to the gland may be produced by them. The above authors point to the fact that Archibald had been unable to produce changes of the pancreas by injection of 0.75 c.c. of bile into a pancreatic duct, and they feel, therefore, that larger amounts of bile produce edema, etc., by physical damage to the gland. As main proof

for their contention, they showed that India ink injected into a pancreatic duct in amounts of 3 c.c. and more could be seen in the interstitial tissue in microscopic sections. We have convinced ourselves that microscopic study of such preparations is inconclusive because India ink is spread over the tissue during the process of sectioning. We cannot explain why Archibald did not obtain changes of the pancreas with 0.75 c.c. of bile, while we were able to produce edema with 0.1 c.c. only; but we feel that Rich and Duff are wrong in their assumption that bile damages the pancreas through the primary physical damage of injection. Since pancreatic enzymes were found regularly in the edema fluid of the pancreas and in the peritoneal exudate, we must assume that a diffusion of pancreatic juice occurred through cell membranes, normally impermeable to it. It is probable that physicochemical changes of the pancreatic ferments are responsible for this diffusion.

TABLE II

HUMAN PERITONEAL EXUDATE

CASE NO.	PATHOLOGIC CONDITION OF PANCREAS FOUND AT OPERATION	PERITONEAL EXUDATE AMYLASE	BLOOD AMYLASE
1	Edema	2,000	128
2	Edema	8,000	1,000
3	Acute pancreatitis with fat necrosis	256	32
4	Acute pancreatitis with fat necrosis	8,000	512
5	Acute pancreatitis with fat necrosis	1,000	64
6	Acute pancreatitis with fat necrosis	512	32
7	Hemorrhagic necrosis	4,000	256
8	Hemorrhagic necrosis	256	32
9	Hemorrhagic necrosis	2,000	128

The above observations are in line with previous experiments and observations of mine[9, 10] which showed that reflux of pancreatic juice into the biliary system may be followed by diffusion or transudation of an activated mixture of pancreatic ferments and bile through the intact walls of the gall-bladder and bile ducts into the peritoneal cavity (Popper[7, 8]).

SUMMARY AND CONCLUSIONS

In artificially produced edema of the pancreas of dogs high concentrations of pancreatic enzymes were found regularly in the subcapsular edema fluid of the pancreas. Edema of the pancreas seems to be due to diffusion of activated pancreatic juice through the intact ducts into the tissues of the pancreas, and not to mechanical rupture of ducts, etc. Large amounts of amylase and lipase were demonstrable in the peritoneal exudate some time after the development of pancreatic edema.

Activated pancreatic juice obviously diffuses into the interstitial tissue of the gland first and later on into the peritoneal cavity. These

same conditions seem to exist in human pathology since in every one of a number of cases of acute pancreatic disease in man examined by me, a high amylase concentration was found in the peritoneal exudate.

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DIFFUSION OF PANCREATIC ENZYMES THROUGH THE INTESTINAL WALL IN ILEUS

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IN PREVIOUS observations on man I have been able to demonstrate that under certain conditions the extrahepatic biliary system may become permeable to bile and pancreatic juice after the latter has entered it by reflux.[1-3] Following this work it seemed natural to investigate whether a mixture of bile and pancreatic secretion, such as would accumulate in the duodenum under conditions of obstruction, would penetrate through the living, unperforated duodenal wall.

The method of our experiments was as follows: In five dogs the duodenum was ligated under nembutal anesthesia just below the pylorus and somewhat below the junction of the accessory pancreatic duct. Thus the portion of the duodenum which contained the openings of bile and pancreatic ducts was shut off from the rest of the intestines without interference with the blood supply. The secretion of pancreatic juice and of bile was then stimulated by intramuscular injection of mecholyl, decholin,* or eserine. The experiment was continued for five to seven hours. At that time the loop was distended and its serosa slightly congested. The loop was excised and opened. It was filled with bile-stained fluid. Its wall and mucosa appeared grossly normal. Histologic examination revealed infiltration of the intestinal wall with round cells, but did not show necrotic or acute inflammatory change and the epithelial lining of the mucosa appeared normal. Neither pancreas nor liver showed any change.

TABLE I

EXPERIMENT NO.	ENZYME	CONCENTRATION IN EXUDATE AFTER					CONCENTRATION IN SERUM AFTER				
		1 HR.	2 HR.	3 HR.	5 HR.	7 HR.	0 HR.	1 HR.	3 HR.	5 HR.	7 HR.
1	Amylase*				1,000		64			256	
2	Amylase			2,000	4,000	512	32			256	
3	Amylase		32		64	64	64	64	64	64	64
4	Amylase		256								
5	Amylase	64		2,000	512	512	32	64	256	256	256
	Lipase†	1.2		2.05	1.45					0.2	

*Wohlgemuth method ($d\ \frac{38}{30}$).[5]

†Crandall and Cherry method.[6]

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*We acknowledge gift of these substances by Merck & Co. and Riedel de Haen respectively.

Two to three hours after the beginning of the experiments, a varying amount of markedly bloody exudate was found in the peritoneal cavity. Determinations of enzymes in the aspirated fluid revealed relatively high concentrations of amylase in Experiments 1, 2 and 5. In Experiment 3 no increased value of amylase was found. In the latter animal the stomach was filled up with undigested foodstuffs, although it had been fasted for sixteen hours; this animal probably was sick. A moderate increase of amylase was found in Experiment 4 already after two hours, but the animal died a short while later, probably due to overdosage of mecholyl.

Determinations of trypsin were not practicable on account of admixture of blood. Only a few determinations of lipase were performed. The presence of high concentrations of amylase was considered to be sufficient to indicate the presence of pancreatic secretions.

Amylase was also determined in venous blood which was drawn at the beginning of each experiment, and in Experiments 1 and 2, five hours, in Experiments 2 and 3, one, three, five, and seven hours after beginning of duodenal obstruction. In Experiments 1, 2, and 5, in which diffusion of pancreatic enzymes into the peritoneal cavity was demonstrable, a moderate increase of blood amylase was found which, however, by far did not reach the value found in the peritoneal exudate. It is interesting to note that in Experiment 3, which did not show an increase of amylase in the exudate, likewise no increase of blood amylase was found.

The question arises what the cause of the increase of blood amylase may be. Since neither gross nor microscopic changes were found in the pancreas, we are inclined to assume that the increase of amylase in the blood is caused by absorption of pancreatic enzymes from the bloody exudate in the peritoneal cavity into the lymph or blood stream; this assumption is supported by the results of Experiment 3. Further research is directed to answer this question.

The findings reported in this paper may throw light on the old question of the mechanism of the increase of pancreatic enzymes in the blood in acute pancreatic diseases. Everybody who had occasion to observe a great number of cases of acute pancreatitis knows that those cases with more peritoneal exudate generally have higher concentrations of amylase in the blood than the more "dry" cases (Walzel).

SUMMARY AND CONCLUSIONS

In five dogs complete obstruction of the duodenum was produced by ligatures just below the pylorus and below the duct of Santorini. The secretion of bile and pancreatic juice was stimulated by drugs. Although the obstructed duodenum was distended, its tissues were not devitalized nor did perforation occur. Pancreas and liver were found

to be normal. Bloody peritoneal exudate contained large amounts of amylase in most animals. Blood amylase gradually increased during the course of obstruction, but it did not reach the values found in the peritoneal exudate. Like in the case of permeability of an intact gall bladder after injection or reflux of pancreatic juice, the intact intestinal wall is permeable to pancreatic enzymes in the case of experimental obstruction. The bearing of these observations on high ileus in the human is evident.

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THE EFFECT OF PREDIGESTED FOOD ON EXPERIMENTAL PEPTIC ULCER

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THE concept that peptic ulcer depends upon some nutritional disturbance or some as yet unknown deficiency seems to have fully as much experimental support as other well-known theories. Weech and Paige[4] found that, of twenty-two dogs which were kept on a low protein diet in a study of nutritional edema, 36 per cent developed a true peptic ulcer. An additional 23 per cent showed superficial erosions of the gastric and duodenal mucosa. Bollman and Mann[1] reported that many animals on which Eck fistulas were produced ultimately died of a peptic ulcer. Furthermore, many experimental procedures designed to test the effect of an unneutralized acidity interfere with the intestinal physiology which, in turn, may alter the animal's nutrition.

It is obvious that drainage of the entire duodenal contents into the lower ileum or exteriorizing the biliary and pancreatic ducts must seriously affect digestion. The ingenious method of Matthews and Dragstedt,[3] by which the gastric juice was conducted through a rubber tube for a distance down the jejunum, would seem to disturb digestion less than many other studies. However, it does not eliminate the possibility that some factor is deranged by the failure of the stomach contents to mix with the other juices at a high level in the tract. Other experiments planned to avoid a disturbance in nutrition produce one or both of two distinctly abnormal conditions: a complete inability of the gastric juices to be neutralized normally, a condition not proved to occur in man; the hydrochloric acid is brought into contact with a portion of the intestines which does not normally receive it. Therefore, a summary of the evidence shows that most of the experimental procedures which produce an ulcer analogous to those which occur in man inject one or more of three phases foreign to man into the situation.

Clinical studies of patients with peptic ulcer do not conflict with the experimental observations. The cyclical behavior of the disease is no different from that of pernicious anemia. The failure of clinicians to recognize any gross disturbance in nutrition would not seem to rule

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out a deficiency as an etiological factor when one considers the prolonged failure to recognize a disturbance in nutrition in such deficiencies as pernicious anemia and beriberi. The fact that there appears to be an ulcer diathesis and some evidence that the disease runs in families is as compatible with the theory of a disturbance in nutrition as with the other suggested causes. Therefore, it seems reasonable to consider the question of nutrition more thoroughly.

It appeared desirable to study this hypothesis by trying to correct the disturbance in digestion resulting in dogs upon which surgical drainage of the duodenum has been performed. That this might be overcome if the animals were given food which had gone through all the normal processes of digestion in the upper intestinal tract of control animals was our premise. Our first problem became one of devising a means for obtaining such food. After several attempts, one of us (R. Z.) contrived a form of fistula which would permit the insertion of a tube in the duodenum of an otherwise normal animal.[5] By this means we were able to obtain sufficiently large quantities of chyme to supply the dogs on which Mann-Williamson operations had been performed.

METHODS OF STUDY

As a preliminary step, high jejunal fistulas were made in three dogs. After the wound had sufficiently healed and the dogs were eating the regular kennel diet of horse meat and bread, food was removed from the jejunum in the following way. The animals were brought into the laboratory and given a quart of milk containing 450 gm. of a prepared dog food, known as checkers. Checkers was used because it is a complete food and because it could be broken into such small pieces that it rarely plugged the aspirating tube. From thirty minutes to one hour after completion of the meal, a tube 11 mm. in diameter was inserted through the fistula into the jejunum. Mild suction was instituted by means of siphon drainage, and the material was aspirated into a bottle. Usually from 300 to 1,000 c.c. could be collected after one meal. The material was alkaline to litmus and was brown in color due to the bile that it contained. The chyme was then stored in the icebox until it was needed to feed the experimental dogs.

After a sufficient amount of this material was at hand, four Mann-Williamson dogs were prepared. These animals were in good health at the time of operation and averaged about 14 kg. in weight. The general routine was the same in all experiments. Approximately one week after operation small feedings of ground horse meat and bread were begun. To this diet supplemental feedings of milk and jejunal chyme were added. Because the animals frequently objected to this food, it was necessary to omit the chyme from time to time and give milk or meat to prevent the animal's losing an undue amount of weight. When anorexia became pronounced, they were fed milk and jejunal juice through a stomach tube.

EXPERIMENTAL DATA

Because each of the four animals used behaved somewhat differently, it is necessary to discuss them individually.

The first dog (No. 1-38) lived for a total of forty-four days, but seemed to do poorly from the beginning, showing little desire to eat at any time. After having refused all food, the dog regained his appetite temporarily on the sixteenth postoperative day, although this was the first day that a black stool was found in its cage. It refused food repeatedly and required feeding by stomach tube, so received much less of the predigested food than the other dogs. It lost weight, declined, and died on the forty-fourth postoperative day. At autopsy the operative wound and anastomosis were found to be in good condition; the junction between the stomach and jejunum was patent; and there was a large jejunal ulcer just distal to the line of sutures.

The second dog (No. 4-38) lived for eighty-nine days and, except for one setback early in its course, ate well, and was the most satisfactory experiment. From 50 c.c. of predigested food given on the seventh postoperative day, the amount was rapidly increased to 450 c.c. Because the dog was losing weight, its diet was increased on the twenty-third postoperative day by adding ground horse meat, milk, and corn syrup. This so upset the animal that the predigested food was omitted. Upon the return of its appetite a week later, the dog averaged 200 to 400 c.c. of predigested food daily until death on the eighty-third day. At autopsy extensive penetrating ulcers were found just distal to the anastomosis.

The third dog (No. 18-38) lived a total of fifty-seven days. On the seventh postoperative day it was started on 100 c.c. of the predigested food plus one quart of milk. At the end of four days the predigested food was increased to 200 c.c. Eleven days later because of a failing appetite the predigested food was decreased to 100 c.c. a day which it took fairly regularly until death supervened thirty-five days later. During most of the time, the dog appeared to do well and to have a reasonably good appetite. However, twenty-eight days postoperatively its appetite suddenly waned. During this time its diet was varied a good deal with the hope that it would be encouraged to start eating again, but the last six days of its life it refused to take any food. Autopsy in this animal showed two large penetrating ulcers in the jejunum adjacent to the line of anastomosis, one of which had perforated and had been sealed off by omentum.

The fourth dog (No. 19-38) lived a total of forty-eight days. It always showed a dislike for the predigested food and ate very little during the first twenty days. It then began to eat food which was not mixed with the gastric juice so that the predigested food had to be given by stomach tube. It went downhill rapidly and at autopsy showed a large superficial ulcer of the jejunum near the pylorus.

DISCUSSION

A perusal of these data shows that the giving of considerable quantities of predigested food appears to have no beneficial effect on the course of the animals on which surgical drainage of the duodenum has been performed. In fact, they failed more rapidly than the usual control Mann-Williamson dog. The four animals lived an average of 8.4 weeks in comparison to an average survival period of 17 weeks reported by Fauley and Ivy[2] for forty-two dogs operated upon by the Mann-Williamson technique and fed a stock diet.

In an attempt to evaluate these results, certain facts should be considered. First, all of the animals varied considerably in their attitude toward food from the very beginning. Two seemed to eat well, even though they lost weight, and their appetites did not begin to fail until after their general condition had become poor. The other two showed a tendency to refuse the diet from the start and were always feeding problems. It is possible that this variation in their attitudes toward food may be explained by the mechanical behavior of the stomach and intestine after the operation is performed. It also is true to some degree that the animals with the best appetites, in general, got along the best until the final days when all went through the same rapid decline.

The second point of interest is that the general course of these animals is much the same. There is a period of time after the operation when they are in good condition. Then comes a second period when the animal is losing weight and shows evidence of inadequate nutrition even though his appetite may be good. At the third stage his appetite fails. The fourth and final stage occurs when evidence of an active ulcer develops, usually signified by the presence of gross blood in the stool.

The third observation is that there is a definite change in the body as far as the protein and some salts are concerned. In two dogs three determinations of the blood proteins were made as long as forty-eight and fifty days after operation. There was a gradual decline in these levels from an average of 6.2 to 3.7 mg. per cent. But the anemia which is always present at the end seems to depend on the loss of blood rather than on the inadequate nutrition. There can be no denying the fact that the Mann-Williamson operation produces an inadequate nutrition in addition to preventing normal neutralization of the gastric juice. The question then arises as to which of these two factors is essentially the more important. It is recognized that the type of experiment which Mann and Williamson first introduced has demonstrated the close association between the hydrochloric acid and the development of a lesion. However, this does not mean that an unneutralized acid is the sole cause of an ulcer in man; nor, so far as we are aware, have these investigators made this contention. Clinical

observations of patients also support the idea that acid is a factor in producing the ulceration in man, but our recent knowledge of peptic ulcer refutes the thought that it is the only, or perhaps the main, cause of human ulceration. Moreover, it usually takes several weeks before the ulcer develops in the experimental animal so that some protective function of the mucous membrane must be lost before ulceration actually develops.

The failure of our experiments to prevent the formation of an ulcer or to prolong the animals' lives does not, of course, disprove the hypothesis which led us to perform these experiments. It is possible that the operation causes the loss of some substance or substances in greater amounts than the normal dog can manufacture from the usual diet. The observation of Fauley and Ivy that a specially prepared diet which, among other things, includes liver and raw pancreas, prolongs the lives of these animals makes it seem possible that the intestinal tract is capable of some digestion and absorption. It might have been of interest to determine what effect the giving of this diet in a predigested form would have had on the experimental animals. Another possibility is that a disturbance in nutrition may arise in the liver or some other organ after actual absorption of food from the tract, which, of course, was not taken into account in these experiments.

SUMMARY AND CONCLUSIONS

Some clinical and laboratory studies have suggested that peptic ulcer may depend upon a disturbance in nutrition. As one way of testing this hypothesis, four dogs upon which a surgical drainage of the duodenum had been performed, as originally devised by Mann and Williamson, were given considerable quantities of food obtained from the upper small intestine of normal dogs. This treatment failed to prolong the expected postoperative course of the animals. However, the fact that Fauley and Ivy have been able to prolong the lives of similar animals with a specially prepared diet suggests that further work along these lines is indicated.

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A TECHNIQUE FOR HIGH INTESTINAL FISTULA

Experimental Method

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RECOVERY of the intestinal secretions over a period of time is desirable in certain laboratory investigations. But since the continued loss of fluids from a high intestinal fistula results in the almost immediate death of the animal, a method which maintains communication with the intestine yet permits retention of its contents, except when aspirated, is vital for any prolonged investigation.

Mann and Bollman[1] have described a procedure for establishing a nonleaking fistula of the small intestine. However, in some recent laboratory experiments in which it was necessary to obtain large quantities of intestinal juice from a point just distal to the duodenum, this method did not fulfill our requirements. We could neither be certain that the drainage tube entered toward the stomach nor could we obtain a sufficient quantity of material. Therefore, we devised a simplified method for establishment of a fistula which was so suitable for our needs that we believe it will prove useful to other investigators.

If a fistulous opening from the stomach is placed near the midline of the back, no secretions are lost because an animal, even at rest, will maintain the opening uppermost. Taking cognizance of this observation by Cope,[2] we planned our operation.

All experiments were carried out under intravenous nembutal anesthesia and sterile conditions. Fine silk suture material was used throughout.

The abdomen was opened, and the ligament of Treitz was divided to mobilize the jejunum. A loop of intestine was then selected at the desired level for the fistula. A lateral anastomosis with a stoma approximately 5 to 6 cm. in length was performed within 5 cm. of the apex of the loop. The loop of intestine beyond the anastomosis was pulled through a stab wound made high in the left flank as far posteriorly as possible. Since high jejunal fistulas, when similarly placed on the right side, were found unsatisfactory because of the continued loss of secretions, the left flank was always used. An opening was made in the mesentery beyond the anastomosis, allowing part or all of the abdominal wall to be approximated through this rent in order

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to prevent the subsequent retraction of the fistulous opening (Fig. 1). The remainder of the wound was brought together loosely about the intestine to avoid interference with its blood supply. The original abdominal incision was carefully closed. The exteriorized intestine was covered with sterile gauze and saturated with collodion.

Because it is unnecessary to divide the ligament of Treitz except for a high jejunal fistula, a loop of intestine for a lower level fistula may be delivered primarily through a stab wound in the left flank without the necessity of an initial abdominal incision. Usually an adequate length of intestine can be mobilized for the performance of a lateral anastomosis and the steps previously described.

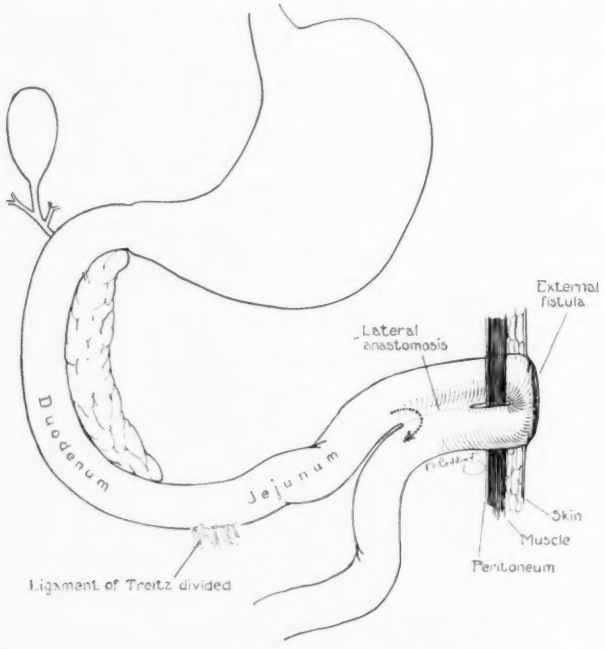

Fig. 1.—Schematic drawing showing fixation of the fistulous opening and the location of the lateral anastomosis.

Seven to ten days following operation, after the wound was well healed, an incision of sufficient size to permit the introduction of a rubber tube as large as 11 mm. in diameter was made in the exteriorized intestine. Only a minimum of drainage occurred at any time from the fistulous opening.

Several days later we proceeded to aspirate the duodenal contents. The dogs were fed milk and checkers (a prepared dog food) about one-half hour before collection was planned. At the time of collection an open-end rubber catheter with several side openings was introduced into the fistulous opening. Through this, mild suction was maintained by the siphon method shown in Fig. 2. The flow of intestinal contents started almost at once and continued until as much as 800 c.c. of duodenal contents were removed in forty-five to sixty minutes,

depending upon the amount fed the animal. Daily intubation proved unwise, because it occasionally initiated bleeding from the fistulous opening.

Following several months of study, some scarring occurred around the opening with resulting constriction, but this did not interfere with continued aspiration. The animals continued in good health.

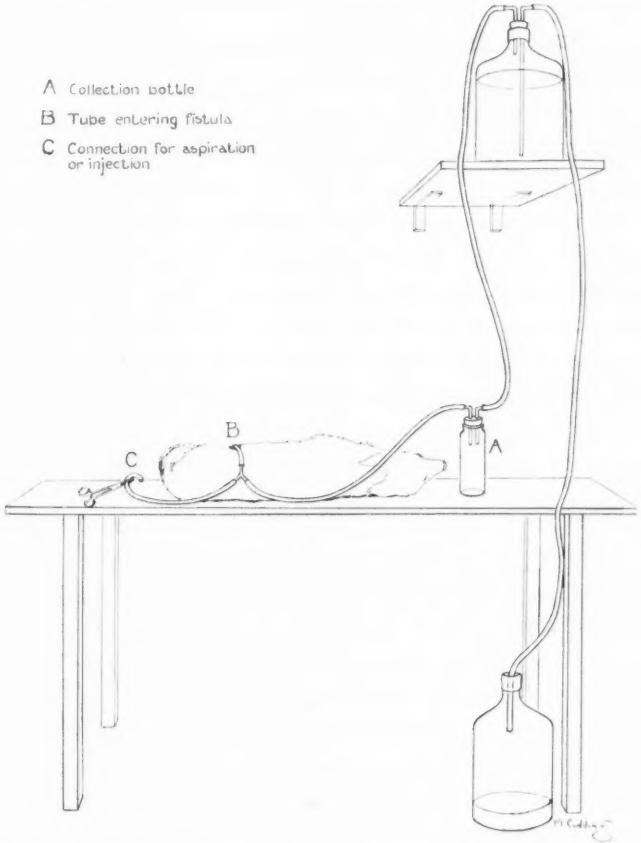

Fig. 2.—Method of obtaining intestinal contents from fistulous opening by means of siphon suction.

CONCLUSIONS

A simplified technique for the establishment of an intestinal fistula has been described. Such a nonleaking fistula permits withdrawal of a fraction or all of the intestinal secretions at the desired level over a prolonged period of time.

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PERITONEOSCOPY IN GUNSHOT AND STAB WOUNDS OF THE ABDOMEN

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IT IS established surgical practice to explore, with rare exceptions,[1] any gunshot or stab wound of the abdomen suspected of entering the peritoneal cavity.[2-5] In borderline cases the decision whether or not to operate is difficult. Wilson[5] suggests that in doubtful cases an upright plate of the abdomen and search for pneumoperitoneum may assist in diagnosis, but that, if doubt still remains, laparotomy is in order. Wright and co-workers[6] describe the procedure now employed at the Harlem Hospital in questioned perforations. An incision is made down to the peritoneum near the entry wound. Then, by peeling away this layer from the overlying fascia in the region of the wound, absence of penetration will be made evident without actually invading the peritoneal cavity. This, however, is still a major procedure.

The number of times that laparotomies performed for bullet or stab wounds reveal no peritoneal perforation is impressive. Taylor[7] reported 13.8 per cent of negative explorations for gunshot wounds at the Indianapolis City Hospital. Wright found that of 153 cases of stab wound with exploration carried down to or through the peritoneum, 10.8 per cent showed no perforation. In the past three years at the Louisville City Hospital, of 114 operations for gunshot or stab wounds of the abdomen, 24, or 21 per cent, were found not to penetrate the peritoneum. It will be seen in Table I that the percentage of negative explorations was even higher (31 per cent) for stab wounds. Analysis of the 24 negative exploratory laparotomies revealed, furthermore, that in all but 1 the peritoneal perforation, if present, could have been visualized by the peritoneoscope.

TABLE I

114 LAPAROTOMIES FOR GUNSHOT AND STAB WOUNDS AT THE LOUISVILLE CITY HOSPITAL, JULY, 1936, TO JULY, 1939

	GUNSHOT	STAB	COMBINED
Penetrating	49	42	91
Nonpenetrating (preventable laparotomies)	4 (7.5%)	19 (31%)	23* (20%)

*There were actually 24 negative explorations. However, in 1 of these the wound site (a stab in the back) would have been inaccessible to peritoneoscopy.

Since February, 1939, we have employed peritoneoscopy to ascertain in these borderline cases whether or not knife or bullet has penetrated

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the peritoneal cavity. Although I have found to date no mention in the English literature of the use of the peritoneoscope in such cases, it seems that there could be no more clear-cut or practical indication for the procedure. Peritoneoscopy is a safe, minor operation, performed under local anesthesia through a stab wound scarcely bigger than that used in the familiar "belly tap." Yet, with but rare exceptions, it is as dependable as a laparotomy in determining the presence or absence of perforation.

Peritoneoscopy (also termed abdominoscopy, celioscopy, laparoscopy, ventroscopy, etc.), first described and practiced upon dogs by Kelling, of Dresden,[8] in 1901, was by 1910 employed upon human beings by both Kelling[9] and Jacobaeus,[10] of Stockholm. In this country it has been little used until rather recently. Perhaps the greatest impetus to its general acceptance in America has been given by Ruddock.[11] By 1937 he had devised a very efficient instrument* and had reported a series of 500 observations with but 1 fatality and with a diagnostic accuracy of 91.7 per cent. Benedict,[12] Thieme,[13] Horan,[14] and others have also recently contributed series of safe and accurate abdominal diagnoses by this method.

INDICATIONS AND LIMITATIONS

Peritoneoscopy is indicated only in those cases of gunshot or stab wounds in which doubt exists whether or not the peritoneal cavity has been penetrated and in which the entry wound, if present, would be within reach of the scope's vision. The entire front wall of the abdomen around to about the midaxillary line on each side and much of the undersurface of the diaphragm can be visualized.

Wounds through the back and up behind the stomach are inaccessible. Fortunately, as pointed out above, few of them are in these latter locations.

Peritoneoscopy is contraindicated where the patient is in desperate condition or where perforation is obvious. Also, this procedure is ill advised in chest injuries suspected of perforating the diaphragm above the costophrenic sinus, because in such cases the air introduced into the abdomen might easily leak up into the pleural cavity. If peritoneal perforation is disclosed, laparotomy is then in order.

TECHNIQUE

A foroblique cystoscope and simple accessories (Fig. 1) proved satisfactory in the five cases here reported. Such instruments should be available even to small hospitals. However, we now use the Ruddock peritoneoscope and find its visibility and range far superior to the cystoscope.

*The Ruddock peritoneoscope, manufactured by American Cystoscope Makers.

The procedure, using our homemade setup, is essentially the same as that described by Ruddock[11] for his special scope, and for details the reader is referred to his article.

1. After local novocain infiltration, a small stab wound is made down to the transversalis fascia at any spot chosen, but usually in the midline just below the umbilicus.

2. While the patient tenses his abdominal wall, a blunt lumbar puncture needle is cautiously pushed into the peritoneal cavity and through it the abdomen is slowly distended with air.

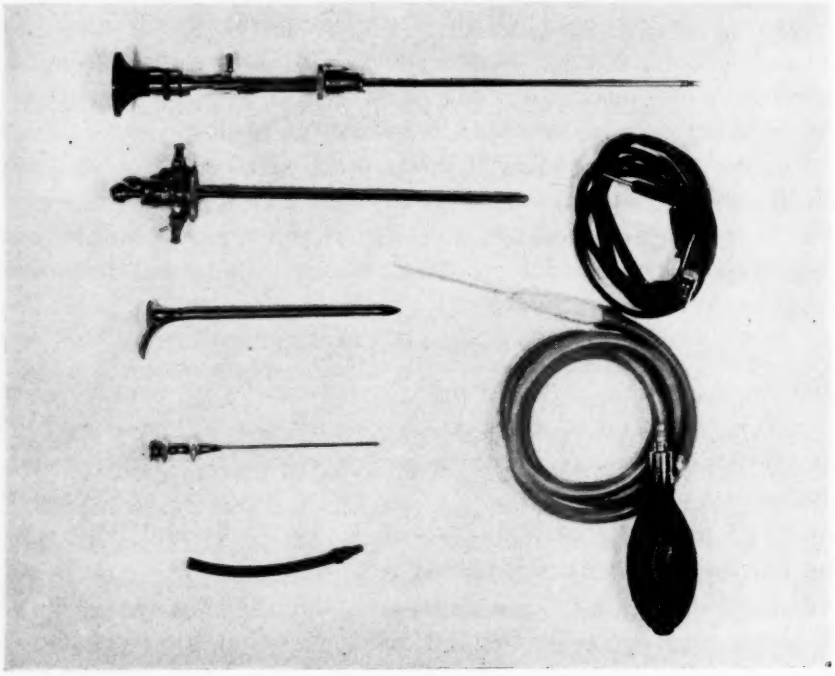

Fig. 1.—Foroblique cystoscope and accessories used in peritoneoscopy.

3. Through the same stab wound, penetration is then safely completed by the trocar which is of the same size as the cystoscope sheath. Upon its withdrawal the scope is immediately inserted. Additional air as needed is injected through the turncock. It will be found that the cystoscope is sufficiently airtight for this.

4. The most important step of the procedure is illustrated in Fig. 2. After the cystoscope has been introduced, a Kelly hemostat is gently poked into the débrided entry wound so as to indent the underlying peritoneum. This localizes the area suspected of perforation. This maneuver, combined with appropriate tilting of the subject to gravitate the viscera, will often allow adequate visualization of regions otherwise inaccessible to the scope. Hemoperitoneum, except when obviously due to instrumentation, is in itself proof of penetration.

CASE REPORTS

CASE 1.—I. H., a 27-year-old colored male, was admitted Feb. 22, 1939. He had been stabbed in the left abdomen one and one-half hours before entry. He denied abdominal pain or hematemesis. On examination he was found to be in good condition, with pulse of 100 and blood pressure of 130/80. The abdomen revealed no spasm or evidence of free fluid. A stab wound was found in the left anterior axillary line 1 inch above the umbilicus. It was 2 cm. in length and surrounded by hematoma. The urine was free of blood. Under local anesthesia the stab wound was excised and peritoneoscopy performed. The peritoneum for

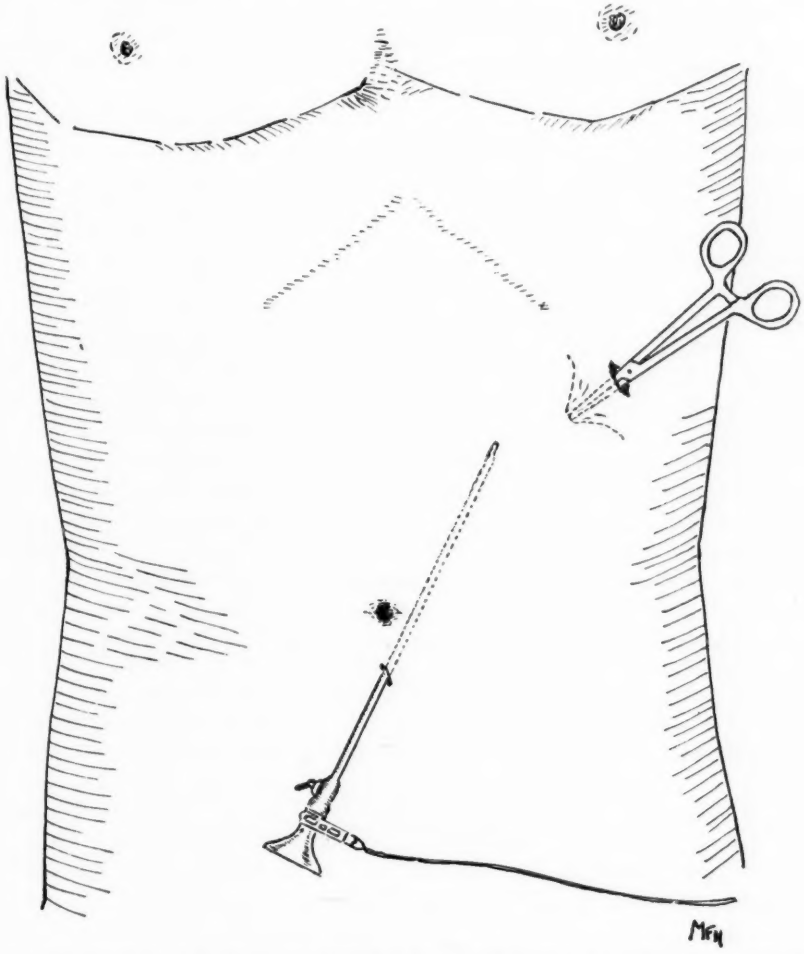

Fig. 2.—Illustration of method of localizing suspected region by indenting peritoneum through débrided entry wound.

a wide area underlying the stab wound was visualized and found to be intact. The patient was able to leave the hospital on the second day following instrumentation.

Comment.—This was a borderline case. Although penetration into the abdominal cavity was unlikely, heretofore laparotomy would have been obligatory to rule it out.

CASE 2.—J. B. was admitted March 11, 1939. This 19-year-old colored male was shot in the left upper abdomen with a pistol twenty minutes before entry. He complained of some soreness in the region of the wound but no definite pain or tenderness and no vomiting. The patient appeared to be in no particular discomfort. His pulse was 100; his blood pressure, 134/76. The bullet entry wound was found just below the ninth left rib 8 cm. from the midline. The exit wound was found just below the twelfth rib in the posterior axillary line. The abdomen was soft and free of tenderness. The urine was grossly and microscopically negative for blood. The patient was given spinal anesthesia and after the bullet wounds had been débrided he was peritoneoscoped. Clear vision of entire region underlying the entry wound precluded peritoneal perforation. On the first two postoperative days his temperature rose to 102 and 101°, respectively, but the chart was flat thereafter and the patient was discharged the fifth postoperative day.

Comment.—In this case abdominal penetration seemed so probable that spinal anesthesia was given in preparation for laparotomy. However, peritoneoscopy rendered the major operation unnecessary. The rather extensive bullet tract and hematoma explain the patient's five postoperative hospital days.

CASE 3.—J. C., a 23-year-old colored male, was admitted March 15, 1939. Thirty minutes before admission the patient had been shot in the upper abdomen with a small caliber revolver. His only complaint was dull aching pain in the epigastrium. He denied hematemesis. The patient was in good condition with pulse of 98 and blood pressure of 140/104. A small bullet entry wound was found just to the left of the midline about the sternoxiphoid junction. No point of exit was found. The abdomen was soft, nontender. No fluid wave was demonstrable and there was no evidence of chest injury or cardiac tamponade. The urine was grossly and microscopically negative for blood. A flat plate of the abdomen showed a small caliber bullet in the right lobe of the liver about 1.5 cm. below the dome. Excision of the bullet wound and peritoneoscopy were carried out under local anesthesia. The telescopic observation was not entirely satisfactory in that many adhesions enveloped the right liver lobe and seemed to be binding it to the under surface of the diaphragm. However, no free blood was seen. The patient was kept in the hospital for ten days because of the bullet wound to the liver. Except for several days of elevated temperature, his course was uneventful.

Comment.—With the point of entry and point of lodgment of the slug in the right liver lobe, injury of any hollow viscus was practically precluded. In this case peritoneoscopy was carried out to ascertain the amount, if any, of intraabdominal bleeding.

CASE 4.—O. S., a 27-year-old negro male, was admitted June 18, 1939, just after having been stabbed in the left abdomen. He denied any abdominal or chest pain, hematemesis, or hematuria. Examination showed that the patient was in no acute distress. His pulse was 80; his blood pressure, 140/70. The abdomen was flat, soft, and free of tenderness. A stab wound 0.8 cm. long and bleeding slightly was found in the left midaxillary line at the level of the tenth rib. The patient was taken to the operating room and the stab wound was excised under local anesthesia. Peritoneoscopy, also under local anesthesia, clearly revealed a perforation at the juncture of diaphragm and lateral abdominal wall underlying the external wound. An exploratory laparotomy was then carried out under spinal

anesthesia. No visceral injuries were found. The postoperative course was uneventful and the patient was discharged on the fifteenth postoperative day.

Comment.—This patient had no signs or symptoms of abdominal penetration. The simple procedure of peritoneoscopy disclosed the perforation and settled any doubts as to the indications for exploration.

CASE 5.—W. H., a 36-year-old colored male, was admitted June 21, 1939. About an hour before admission this man had been stabbed in the lower midchest. External bleeding had been profuse and the patient's clothing was drenched with blood. He denied hematemesis, hemoptysis, or symptoms of hemothorax or cardiac tamponade. Examination revealed a patient in shock with pulse 120 and thready and blood pressure unobtainable. His respirations were normal. A transverse lacerated wound 3 cm. long was found in the sixth interspace 2 cm. to the left of the sternum, not bleeding or sucking. The heart sounds were distant. The venous pressure was 5.5 to 7.5 cm. of water. The abdomen was soft with no spasm, tenderness, or evidence of free fluid. Fluoroscopy gave no evidence of heart or chest injury. The patient was given a transfusion of 500 c.c. of citrated blood and in addition parenteral glucose, so that within one and one-half hours his blood pressure was 160, his pulse 110, and his general condition much improved. Then under local anesthesia the stab wound was carefully débrided and peritoneoscopy carried out. The abdominal air inflation was very cautiously carried out, since the knife blade might have passed through the left anterior costophrenic sinus, and thus have allowed some leakage of air into the left pleural cavity. However, no untoward results were observed. A probe passed through the stab wound could be seen indenting the peritoneum on either side of the falciform ligament, but there was no perforation of the abdominal wall or diaphragm. The patient's postoperative course was uneventful and he was discharged on the fourth day.

Comment.—It was suspected that the abdominal cavity had been penetrated and that there was internal hemorrhage from a lacerated liver and possibly injury to hollow viscera. Peritoneoscopy here obviated a major procedure in a partly exsanguinated patient.

SUMMARY

1. Gunshot or stab wounds suspected of perforating the peritoneal cavity should be explored.

2. The decision whether or not a gunshot or stab wound has perforated is often difficult.

3. A surprisingly large number of laparotomies are performed without finding any perforation.

4. Peritoneoscopy is suggested as a safe and reliable method of determining the presence or absence of perforation in the doubtful cases.

5. Reports are presented of five cases successfully managed in this manner.

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HISTOPATHOLOGY OF OLD ANASTOMOTIC WOUNDS OF THE GASTROINTESTINAL TRACT*

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(From the Mayo Foundation)

NUMEROUS workers have described the process of healing of anastomotic wounds of the upper part of the gastrointestinal tract of experimental animals, and two workers, Marchand[7] and Angerer,[1] have described the process of healing in comparatively recent anastomotic wounds in the human being, but no comprehensive attempt has been made to study old anastomotic wounds in man.

Marchand in describing very briefly a six-day-old wound following gastroenterostomy mentioned the adhesion of the serosal surfaces by fibrin, the thick muscle layer on the stomach side of the anastomosis, the partial regeneration of the epithelium, cellular infiltration, and damage to the muscle in the region of the sutures, consisting of swelling of the individual muscle fibers. Glandular remnants were noted deep in the mucosa at the point of juncture of the intestine and the stomach.

Angerer[2] in 1927 described the histologic appearance of tissue from the site of three gastroenterostomies performed two and more years before the death of the patients. On gross examination he noted a bunching up of the gastric mucous membrane which protruded slightly through the anastomotic ring. The epithelium on the stomach side of the anastomosis was normal except for dilated cystic pyloric glands with tortuous gastric foveoli. Lymphocytes were present throughout the mucous membrane. The transition zone from gastric to intestinal mucosa was in places sharply defined and in others the change was gradual and there was an intermingling of intestinal and gastric glands. On the intestinal side the epithelium was rich in goblet cells with deep crypts of Lieberkühn, in the sides and bases of which were Paneth cells. His most remarkable finding was islands of what appeared to be normal gastric mucosa in the midst of the intestinal mucosa. The severed ends of the muscularis were united by scar tissue. The smooth muscle layers ended in whirls bound together by fibrous tissue.

Histologic observations on gastrointestinal anastomoses in the experimental animal have been made by many investigators, among them Barbat, 1899; Gould, 1906; Flint, 1917; Grey, 1918; Sabin, 1920; Webster, 1924; Nemiloff, 1925; and Martzloff and Suckow, 1935. Their

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observations gave evidence of (1) destruction and regeneration of the mucosal epithelium, (2) mucosal cysts and suture inclusions, (3) a difference of opinion as to whether there is regeneration of the muscularis mucosae, (4) severe damage to the muscularis propria and a difference of observation as to the extent of regeneration, and (5) extensive pattern of blood vessels in the infolded serosal margin shortly after the operation.

MATERIAL

The gross and microscopic examinations of tissue* from the site of 81 surgical anastomoses of the stomach and upper portion of the small intestine were made. In 8 cases tissue was obtained from the sites of enteroenteric stomas made from one day to five years before death of the patient; in 24 the tissue was from the site of a gastrojejunal stoma of the Polya type made from five days to seven years before death of the patient; in 7 it was from the site of a gastroduodenal stoma of the Billroth I type made from one day to six and one-half years before death of the patient; and in 42, from the site of stomas left after gastroenterostomy performed from eighteen days to twenty-seven years before the death of the patient. Emphasis was placed on the study of old anastomoses; that is, those which had been present for two months or longer at the time of the patient's death. Most of the anastomoses were several years old; the oldest was twenty-seven years.

After examination of each gross specimen, a block of tissue was cut from what was considered a representative portion of the anastomotic ring. Sections 8 μ thick were then cut perpendicular to the line of the anastomosis at three different levels in each block and stained with hematoxylin and eosin. In special cases the Galantha mucin and the van Gieson stains were used.

OBSERVATIONS

The exact site of an anastomosis was not difficult to determine, even on gross examination of a specimen long preserved in formalin.

In the performance of an intestinal anastomosis, serous coat is opposed to serous coat; an infolding of the intestinal wall results which at first is prominent. It later becomes less prominent but persists indefinitely as a slight thickening at the anastomotic ring (Fig. 1). This thickening can be demonstrated by cutting through the intestinal wall in a plane perpendicular to the line of anastomosis and examining the cut section. In such fashion the anastomotic site can be located easily. Fig. 1 reveals this infolding and thickening of the intestinal wall at the anastomotic site two years after an enteroenterostomy.

*A few of the specimens were obtained at necropsy during my association with the Section on Pathologic Anatomy of the Mayo Clinic. Most of them, however, came from the museum of the Mayo Clinic, having been collected over a period of ten years, 1927 to 1937.

On examination of the tissue at the line of anastomosis used in a gastroenterostomy, the manner in which the gastric mucosa rolls through the anastomotic ring onto the intestinal side of the anastomosis is usually noticeable.

After an anastomosis between the stomach and small intestine, there is first a destructive phase during which the injured tissue at the anastomotic site is removed. A regenerative phase follows in which new epithelium from the gastric glands and the crypts of Lieberkühn extends over the defect left by the sloughing of injured mucous membrane. Attempts to make sections of the destructive phase for microscopic examination were difficult and the result may be misleading as the only tissue from the site of recently made anastomoses (those performed a few days previously) which was available for study was necessarily from cases in which death had occurred shortly after the operation. In these cases the two pieces of bowel were held together

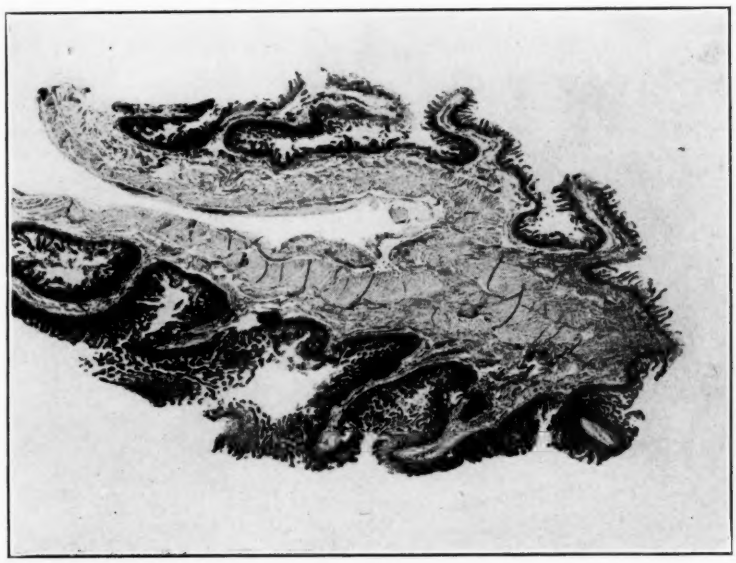

Fig. 1.—Tissue from site of enteroenteric stoma two years old. Patient was 75 years old. Note the infolding and thickening of the wall. (×6.)

largely by suture material and fibrin and were easily pulled apart in cutting the section. The defect between the ends of bowel in such cases was filled with injured mucosa, inflammatory exudate, and regenerating epithelium. Collections of polymorphonuclear leucocytes about the suture material were common. This picture must be somewhat modified in the cases in which recovery ensues. In such instances the regenerative process probably proceeds more rapidly, destruction is not so marked, and the two pieces of intestine are more firmly united than they are in the cases in which death intervenes.

Regenerated epithelium at the point of anastomosis rarely, if ever, was found to resume its preoperative appearance. This was par-

ticularly true of the gastric side of a gastrointestinal anastomosis where the condition was suggestive of chronic gastritis. The glands were shallow, their regular arrangement was disturbed, and they rested on connective tissue or muscularis propria rather than on the muscularis mucosae. Cysts were often seen in the gastric mucosa, but they were absent from the intestinal mucosa in the specimens examined.

These cysts were lined with low cuboidal epithelium (Fig. 2). They have been considered to be caused by the downgrowth of epithelium at points where the mucosa was injured at operation either by penetration by suture material or by actual section of the intestinal wall. Such cystic change was fairly common and was not transient. The latter was proved by its presence at the site of the oldest gastroenteric stoma in this series; gastroenterostomy had been performed twenty-seven years before the patient's death. The largest cysts discovered in this study are shown in Fig. 2. In one case (Fig. 3) a large cyst, lying within the musculature of the bowel wall, was observed. Its lining epithelium of low cuboidal cells took the Galantha mucin stain and therefore was proved to be of a mucous secreting type.

Fig. 2.—Tissue from a gastroenteric stoma twenty-one years old from a man 58 years of age. Note cyst lined with low cuboidal epithelium. (×25.)

Hyperplastic change was noted in the gastric mucosa adjacent to the gastrointestinal stoma in one case (Fig. 4), but there was no evidence of malignant change at the site of any of the anastomoses observed.

In most cases in my series of old gastrointestinal anastomoses the transition from intestinal to gastric epithelium was abrupt so that a specific gland could be said to be definitely intestinal and the one ad-

jacent to it to be gastric. In some cases, on the gastric side of the anastomosis, at the juncture of intestinal and gastric epithelium glands, not unlike Brunner's glands in appearance, which stained clear and pale with hematoxylin and eosin, were present. The Galantha mucin stain revealed them to contain mucin. Their nuclei were small, smaller than

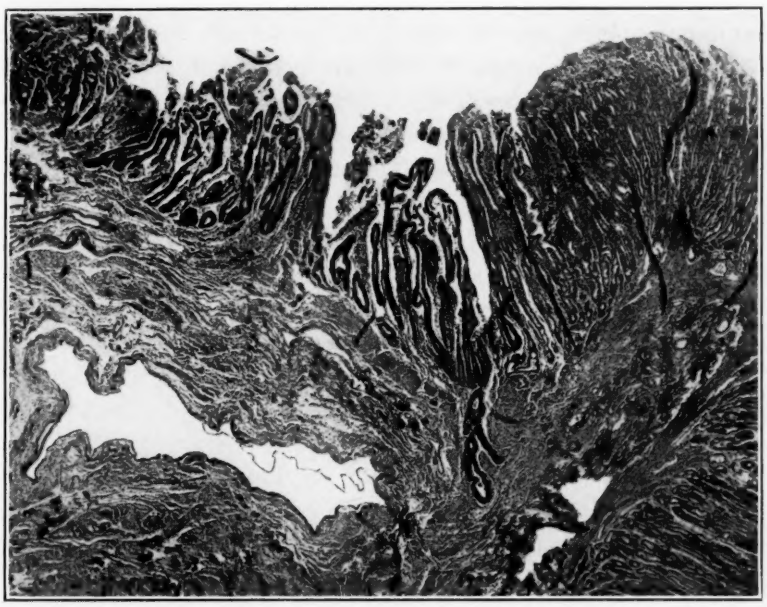

Fig. 3.—Tissue from site of gastrojejunal stoma, forty-five days old. Patient was 46 years old. Note large cyst in musculature of wall and downward extension of mucosal glands at site of anastomosis. (×20.)

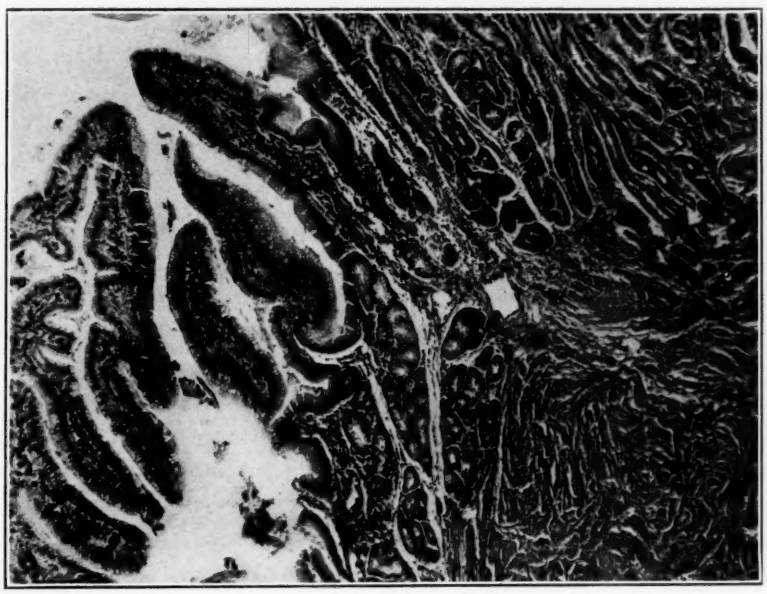

Fig. 4.—Tissue from gastroenteric stoma nine months old. Patient was 40 years of age. Note hyperplastic change in gastric mucosa adjacent to line of anastomosis. (×50.)

those of parietal and Paneth cells, were flattened, and lay near the basement membrane. For want of a better name these glands will be referred to as "undifferentiated glands." By starting at the juncture of gastric and intestinal epithelium and working toward the stomach it was possible, in some cases, to demonstrate the gradual appearance of more and more parietal cells in the undifferentiated glands until the undifferentiated glands were replaced by typical gastric glands. The undifferentiated glands probably represented the fundamental mucous gland of the gastrointestinal tract. Their appearance at the anastomotic site is not always transient, for they were observed at the site of one anastomosis which had been made more than four years before death of the patient.

In the intestinal mucosa adjacent to an old gastrointestinal anastomotic site, there was no appreciable change. Paneth cells occurred up to the point of anastomosis and the crypts of Lieberkühn in the tissue differed in no way from those seen farther from the anastomotic site. In anastomotic sites in experimental animals, Sabin found an increase in mucous cells in the crypts of Lieberkühn for as long as fifty to seventy days after operation. No such increase in mucous cells was present in the old anastomoses of this series.

In the gastric mucosa parietal cells occurred up to the point of anastomosis but were present in diminishing numbers in the few gastric glands adjacent to the anastomotic site. In several instances parietal cells were absent in the immediate vicinity of the anastomosis but were present a few millimeters from it.

When the wall of the stomach or small intestine is severed, there is a retraction of the muscularis mucosae, leaving a defect into which the mucosal glands sag or actually grow downward. In two cases examined such a downgrowth of mucosal glands was noted (Fig. 3). Flint said that the muscularis mucosae regenerates in about two weeks and in doing so dips under the mucosal glands and restores them to their proper position. In man this is not always the case. In one case (Fig. 3) in which a gastrojejunostomy had been performed forty-five days before death the downward extension of the mucosal glands at the anastomotic site still persisted.

One of the easiest ways to locate the anastomotic site in examining microscopic slides of old intestinal anastomoses is to follow the muscularis mucosae until a change in its configuration is reached. This change will indicate the anastomotic site. In every case I examined, with one exception, the muscularis mucosae was abnormal or was absent, mixed with connective tissue or fused with the underlying mass of muscle and scar tisue which joined the severed ends of the muscularis propria.

In the one case in which the muscularis mucosae appeared normal at the site of the anastomosis, enteroenterostomy had been performed

four months before death and the segments of bowel were united by almost normal-appearing epithelium and muscularis mucosae. The muscularis mucosae was a discrete band of tissue which was not fused with the underlying muscle coat or mixed with scar tissue as was usually the case of the anastomotic site. The ends of the muscle coats were separated but connected by a thin layer of scar tissue which lay just beneath and parallel to the muscularis mucosae. As a result of the almost complete absence of muscularis at this point, the thickness of the bowel wall was reduced by more than two-thirds and consisted of mucosa, muscularis mucosae, and a thin layer of scar tissue and muscle covered by serosa. This one case presented the most marked separation of the muscle coats that was noted in any of the cases examined. Yet even with this amount of separation the stoma appeared to have functioned satisfactorily. In a few cases a slight bunching or thickening of the muscularis mucosae was found adjacent to the anastomotic site.

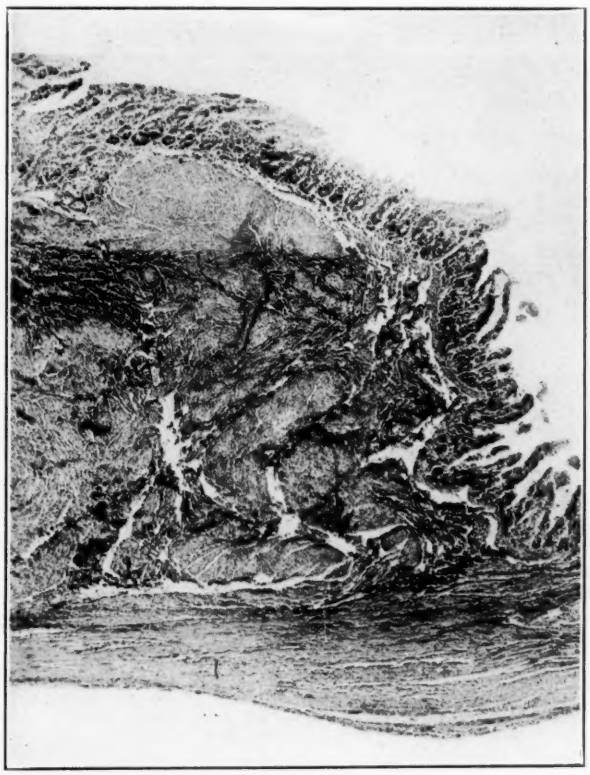

Fig. 5.—Tissue from site of a gastrojejunal stoma of the Polya type. Operation was performed seven years earlier. Patient aged 50 years. Note regeneration of longitudinal muscle and thickened, retracted end of muscularis mucosae. (×25.)

As has been noted by previous observers, the ends of the muscular coats of the intestinal wall were found to be united by a narrow band of scar tissue interspersed with muscle fibers from the muscularis

propria. On this band of scar tissue and muscle the glands of the regenerated mucosa rest. The fibers of the muscularis mucosae were intermingled with, and usually disappeared into, this band of scar tissue and muscle fibers.

As a general rule there was no regeneration of the muscularis propria and its ends were united by scar tissue. In one case (Fig. 5) the longitudinal layer of smooth muscle extended past the anastomotic site, giving the appearance of a regeneration of the longitudinal muscle. Webster noted, after an interval of sixty-eight days, such a regeneration of longitudinal muscle in the experimental animal.

Silk suture material was seen at the site of the anastomosis in several of the cases and, as described by Sabin for the experimental animal, was surrounded by a characteristic foreign body reaction consisting of giant cells and lymphocytes. The oldest anastomosis to show such a reaction was three months old. In recent anastomoses small abscesses surrounding the sutures were common and such an inflammatory reaction rarely persisted for as long as four months.

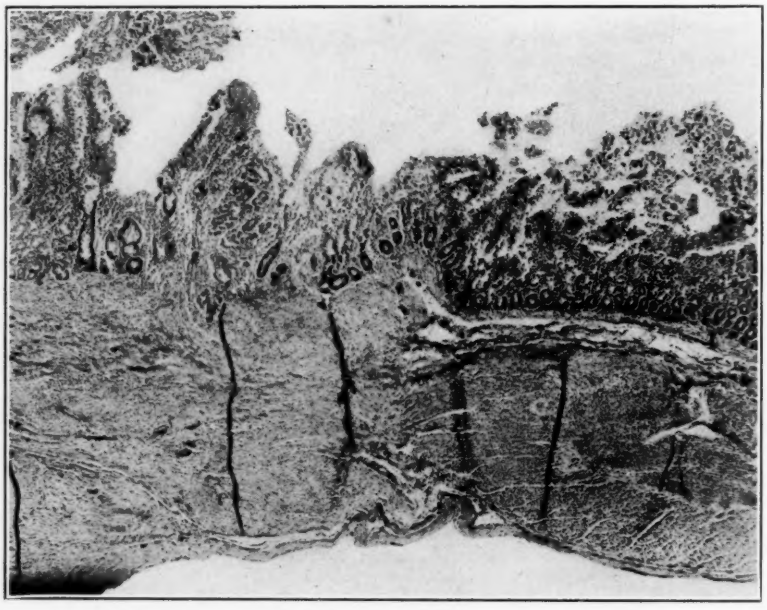

Fig. 6.—Tissue from site of a gastroenteric stoma three months old. Patient was aged 52 years. Tissue at line of anastomosis is most nearly normal of any in series. Note mucosal glands lying directly on band of scar tissue and muscle which unites the severed ends of the muscularis propria. (×25.)

In Fig. 6 an anastomotic site is shown which more closely resembled the bowel before operation than any other observed during this study. Cysts of the mucosa were absent and there was a minimal derangement of the glands, but the amount of connective tissue in the mucosa was increased and the vascularity of the segment of bowel diminished. The mucosal glands were decreased in number and because of the absence

of muscularis mucosae rested directly on the mixture of scar tissue and muscle fibers which united the cut ends of the muscularis propria. The mucosa of this, as of most of the anastomotic sites, resembles that seen in cases of chronic gastritis.

COMMENT

When one considers the amount of tissue infolded in the performance of an anastomosis of the gastrointestinal tract, the necessary trauma incident to the completion of such a procedure, the amount of damaged tissue which must be removed and replaced, and the fact that the field is potentially infected, it is remarkable how few changes are found at an old anastomotic site and to how small a region these changes are confined.

Surgeons who perform intestinal anastomoses should keep in mind the fact that there is probably no such thing as union of the severed ends of intestine by primary intention. There is always a destructive phase during which the injured tissue at the anastomotic ring is cast off and regeneration of the epithelium begins. Every effort should be made to minimize the trauma which accompanies the performance of an intestinal anastomosis. During the destructive phase, when the ends of the bowel are joined loosely, it is important that tension on the suture lines, caused by distention of the viscus, be avoided.

SUMMARY AND CONCLUSIONS

Tissue from the site of 81 anastomoses involving the stomach and jejunum of man was studied grossly and microscopically.

At the site of recent anastomoses there is an early destructive phase characterized by the sloughing of injured tissue and the beginning of the process of repair. Collections of polymorphonuclear leucocytes about the suture material are common. At this time, too, union of the cut ends of bowel is fragile and strain on the suture line must be avoided.

In tissue from the site of old anastomoses the anastomotic site can be located easily on gross and microscopic examination.

Cystic changes are present in the gastric mucosa but not in the intestinal mucosa in the anastomotic ring. There is a diminished number of parietal cells in a few gastric glands adjacent to the anastomosis, and glands of undifferentiated or fundamental type are seen at the junction of gastric and intestinal epithelia. The glands extend downward at the site of injury to the muscularis mucosae, and the muscularis mucosae usually is absent or intermingled with scar tissue and muscularis propria. Union of the muscularis propria is by a thin band composed of a mixture of connective tissue and smooth muscle. The vascularity of the anastomotic site is diminished and there is a foreign body type of reaction about suture material.

When the amount of trauma necessary to the completion of an anastomosis is considered, it is remarkable how few are the changes at an old anastomotic site and to how small a region these changes are confined.

Dr. H. E. Robertson gave me many invaluable suggestions and much advice during this study which I deeply appreciate.

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SYNDACTYLISM WITH ABSENCE OF THE PECTORALIS MAJOR

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IN A group of patients with syndactylism the somewhat surprising added anomaly of absence of the pectoralis major was noted several times. It was considered that the defect possibly might be one of atavism from the recognition that the hand mechanism extends up through the shoulder joint, and that an interference with the prehensile qualities in the hand might be expressed also in the shoulder mechanism to cause absence of the pectoral or hugging muscle.[1] This theory was soon known to be wrong, but it is mentioned here as a slight matter of interest.

It was evident that webbed fingers and the absence of the pectoral muscle in the same patient was not a frequent finding, and, on consulting known authorities, it was found that in the patients of Kanavel, Koch, and Mason[2] the same anomalies were observed in one out of thirty-four patients. Although this was found only in a table, with no mention of it in the text, it has been definitely recognized and recorded by these surgeons.

Davis and Germain[3] presented a complete paper on the subject of syndactylism and listed many other concurrent deformities, but they did not include the absence of the pectoralis major. The same is true of a short article by Dorrance and Bransfield.

Christopher[4] has given a very short case report of the double anomaly, but it has probably been overlooked because only the absence of the pectoral muscle was put in the title.

From the rather limited literature on the subject, it appears conclusive that accidents to the limb-bud formation account for the deformities. A summary of the findings in the patients of Kanavel, Koch, and Mason is that all congenital malformations of the hand are thought to be disorientations of the growth of the limb bud, not sufficient to cause destruction, but not an atavism to an amphibian type. Amniotic bands, any reversion to type, and, in fact, all other suggested etiologic factors are eliminated except impairment of germinal cells.

The combination of pectoral absence and syndactylism has been mentioned in several case reports in the foreign literature, but only one paper has been found with the anomaly mentioned in the title, Bierens de Haan.[20] Bing[21] reported the presence of syndactylism in fourteen out of 102 patients with pectoral absence, and Pol[15] collected twenty such patients. There have been two pictures published of patients with pectoral defects and webbed fingers.[22, 23]

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More than 300 patients with congenital absence of part or all of the pectoral muscle group have been reported, but the true incidence of the lesion is unknown as the deformity is often not obvious and is discovered only by careful examination of the shoulder area. The lesion is usually not disabling and frequently has not been discovered by the patient or his family. One case has been noted of a pectoral absence on the right in a right-handed professional fencer.

Complete absence of the pectoralis major is rare, absence of the sternocostal portion with or without absence of the pectoralis minor being the usual lesion. Clinically these patients present an absence of the normal, well-developed, curved, anterior axillary fold. (Fig. 1.) A few patients have a band of scar tissue forming a web over the anterior surface of the axilla, and this may limit abduction of the arm. (Fig. 2.) There has been only one bilateral case reported and only one instance in which the deformity was hereditary.[12]

Fig. 1. Fig. 2.

Fig. 1.—Absence of pectoralis major and syndactylism, right.

Fig. 2.—Replacement of pectoralis major with a fibrous band which was excised at the time of operation on the webbed fingers.

Associated congenital anomalies of the homolateral hemithorax and upper extremity are quite common. About one-fourth of the patients have rib or costal cartilage defects[13] and about one-third of the women have breast defects. The rib and costal cartilage defects have in some instances been so extensive as to produce a visible mass by herniation of the lung. Sprengel's deformity is occasionally associated with absence of the muscle. In 171 cases of pectoral deficiency collected by Bing and Gundlach, cited by Laan,[13] there was shortening of the upper extremity in thirty-three cases and there were deformities of the hand in twenty-seven cases. The hand anomalies seen were syndactylism, brachydactylism, absence of the metacarpals, and one case of "intra-uterine amputation" of the hand. In Polland's case, cited by Pol,[15] there was associated absence of the pectoralis major and external abdominal oblique with syndactylism. In Furst's[16] case there was total absence of the pectoralis major and minor, partial absence of the serratus anterior,

external abdominal oblique, latissimus dorsi, and intercostales together with deformity of the breast and subcutaneous fat of the chest wall.

There have been several theories advanced as to the etiology of pectoral defects; the most quoted explanation is that of Lewis. He found that in the 9 mm. human embryo the pectoral muscle mass is largely above the first rib. In the 11 mm. embryo it extends lower, but it is still undifferentiated into its component parts and is not attached to the ribs or humerus. In the 16 mm. embryo the clavicular portion is split off and the remainder then divides into the sternal portion and the pectoralis minor. Perhaps the failure of the primitive mass to attach itself to the ribs and sternum might allow its not becoming differentiated into its normal component parts. This coincides with the known fact that the defects are usually in the caudal portion.

It is also known that the pectoralis major develops from the fifth, sixth, seventh, and eighth central myotomes. This suggests that some developmental accident occurring in the seventh and eighth myotomes might result in the syndrome of absence of the lower portion of the pectoralis major and the entire pectoralis minor, together with deformity of the hand.

The patient shown in Fig. 1 is a good example of the typical deformity of absent pectoral and syndactylism and may have absence of the clavicular head of the muscle as well. There is also some degree of reduction of size of the forearm and hand. The patient shown in Fig. 2 had a fascial band slightly limiting the motion of the arm and this was excised at the time of operation on the hand.

Neither of these patients has any subjective or objective impairment of movement or function. Four other patients with the same anomalies have been seen, but the incidence has not been determined in the entire series of webbed fingers that have been operated upon.

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RENAL COLIC CAUSED BY EARLY OBSTRUCTION OF THE LOWER URINARY TRACT

With a Report of 9 Cases

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DILATATION of the upper urinary tract is observed frequently in the presence of prolonged obstruction of the lower urinary tract. Although this type of hydronephrosis and hydroureter is usually painless at its inception, we have come to recognize a small group of patients who, during the early stages, experience colic.

In these cases symptoms referable to the kidney or ureter are so predominant that attention is likely to be diverted from the underlying abnormality. The clinical importance of recognizing the true etiological factor is obvious. It is our purpose, therefore, to describe this syndrome and to discuss the pathologic mechanism of its production.

We have observed nine patients who experienced pain referable to the kidney or ureter which could be explained only on the basis of early obstruction of the lower tract. In every instance a careful urological investigation revealed some type of obstruction of the vesical neck and pointed to a narrowing of the intramural portion of the ureter. The salient features of these nine cases are summarized in Table I.

CLINICAL ASPECTS

Symptoms.—It will be noted that the pain experienced is usually typical of renal colic. Although it may arise in the region of the kidney, the ureter, or the external genitals, all of these areas are likely to become involved in its final radiation. Occasionally the pain is induced by the act of urination, but for the most part there is no relationship to voiding. A dull, aching renal or ureteral pain is less common than colic. The right and left sides are involved with equal frequency. Bilateral pain has not been observed. Although most of the patients of this series were seen in their first seizure, in a few instances recurrent attacks had occurred and one patient complained of intermittent aching pain in the left iliac fossa of seven years' duration.

Careful questioning is required in order to elicit symptoms of obstruction of the lower urinary tract. These symptoms are so much less dramatic than colic that patients are prone to minimize, if not

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completely ignore, them. With some effort on the part of the examiner, however, a history of nocturia, frequency or difficulty in urination can usually be obtained.

Physical Examination.—Tenderness over the affected kidney or ureter is the common finding on physical examination. In view of the incipient nature of the urinary obstruction, rectal examination does not ordinarily disclose any marked degree of prostatic enlargement.

Urological Investigation.—Upon cystoscopic examination, an early form of encroachment on the vesical neck is to be anticipated. It should be noted that in all of the cases of this series there was some involvement of the posterior commissure, either in the form of a median bar, a median lobe, or a contracture of the vesical neck.

The bladder shows the changes of early hypertrophy which constitute its response to obstruction. This changed physiologic state is reflected in a decreased capacity and a small amount of residual urine. There is trigonal hypertrophy (secondary to a posterior commissural obstruction, as discussed later) and trabeculation of the vesical wall (evidence of hypertrophy of the detrusor). Large amounts of residual urine and the presence of cellules and diverticula are manifestations of a later stage of obstruction and are not commonly seen in this syndrome.

The interureteral ridge may be sufficiently hypertrophied to form a well defined bas-fond. The ureteral orifices are lengthened and slit-like, often appearing as very fine, barely perceptible lines (Fig. 1*A* and *B*). In some instances free motility of the orifice is absent and urine is seen to escape from the affected ureter in a stream entirely lacking in projectile force. This phenomenon was carefully observed in some of our patients following the administration of indigo carmine intravenously.

In no instance was there cystoscopic evidence of cystitis or of inflammatory reaction surrounding the ureteral orifices which might have accounted for ureteral obstruction. Even in the two cases in which the urine obtained from the bladder was found to contain pus cells and organisms, the infection was so mild that no gross inflammatory change was discernible.

Upon attempting to catheterize the affected ureters, considerable difficulty is encountered in mounting the intramural portion. A No. 6 ureteral catheter cannot be forced through this region, as a rule, unless it is made rigid with a wire stylet. In one instance, however, it was possible to force a No. 8 olive-tipped catheter through the obstructed area; whereas the more pliable smaller size could not be introduced. In another case, in which a ureteral calculus was suspected, it was found that spinal anesthesia produced sufficient relaxation to permit catheterization with a No. 6 catheter, which previously had been found impossible. When the intramural portion of the ureter has been passed, a steady flow of urine often escapes from the catheter, indicating a

TABLE

SUMMARY

CASE NO.	SEX AGE	SYMPTOMS	PHYSICAL EXAMINATION	LABORATORY DATA	CYSTOSCOPIC	
					LOWER TRACT	MIDTRACT
1	55 M	Excruciating pain in right lumbar region for 24 hr.; no association with urination Past history: nocturia, frequency and hesitancy for 1 yr.	Suffering from severe pain and tenderness over right kidney Rectal examination: prostate not enlarged	Urine: no W.B.C., R.B.C., or organisms; P.S.P.* normal	Median fibroglandular bar	R.U.,† 25 c.c.; B.C.,‡ 300 c.c.; trabeculation of bladder; hypertrophy of trigone; urine lazes from taut right orifice
2	36 M	Severe pain in right iliac fossa for 24 hr.; started when patient attempted to void Past history: frequency and hesitancy of urination for 2 mo.	Tenderness over right kidney and ureter Rectal examination: prostate not enlarged	Urine: no W.B.C., R.B.C., or organisms P.S.P. normal	Contracture of vesical neck	R.U., 40 c.c.; B.C., 250 c.c.; early trabeculation of bladder; hypertrophy of trigone; urine lazes from right orifice
3	63 M	Attacks of severe right lumbar pain associated with increasing difficulty of urination for 2 yr.; pain radiates to inguinal region and right testicle	No tenderness over either kidney Rectal examination: prostate enlarged to 1½ times normal size	Urine: no W.B.C., R.B.C., or organisms P.S.P. normal	Median lobe prostatic hypertrophy	R.U., 75 c.c.; B.C., 450 c.c.; trabeculation of bladder; hypertrophy of trigone (Fig. 1 *A*)
4	75 M	Severe left lumbar pain, radiating to inguinal region and penis, of 2 days' duration Past history: small urinary stream for 1 yr.	Tenderness over left kidney Rectal examination: prostate enlarged to 3 times normal size	Urine: many W.B.C. and motile rods P.S.P. normal	Trilobed prostatic hypertrophy; small intravesical median lobe, large intraurethral lateral lobes	R.U., 60 c.c.; B.C., 300 c.c.; trabeculation of bladder; hypertrophy of trigone (Fig. 1 *B*)
5	49 M	Excruciating pain over left kidney, gradually subsiding over 3-day period Past history: nocturia up to 3 times and small urinary stream for 3 yr.	Tenderness over left kidney Rectal examination: prostate slightly enlarged	Urine: no W.B.C., R.B.C., or organisms P.S.P. normal	Fibrous median bar	R.U., 50 c.c.; B.C., 300 c.c.; trabeculation of bladder; hypertrophy of trigone; taut orifices

**P.S.P.*, Total phenolsulphonephthalein renal function test.

†*R.U.*, Residual urine.

‡*B.C.*, Bladder capacity.

§*K.U.B.*, Plain x-ray of kidneys, ureters, and bladder.

I

OF CASES

FINDINGS				
UPPER TRACT	X-RAY FINDINGS	TREATMENT	PATHOLOGIC REPORT	RESULT AND FOLLOW-UP
Extremely difficult to mount intramural portion of right ureter; relief of pain upon passing catheter; good function, no infection, either kidney	K.U.B.§ negative; pyeloureterogram normal (Fig. 2*A*)	Transurethral prostatic resection; right ureteral meatotomy	Prostatic tissue showing chronic inflammation	2 mo.: patient asymptomatic; R.U., 0 Cystoscopy: site of resection and meatotomy well healed; ureter easily catheterized; trigonal hypertrophy and trabeculations less marked
Stylet required in mounting intramural portion of right ureter; good function, no infection, either kidney	K.U.B. negative; bilateral pyeloureterogram negative	Transurethral resection of vesical neck; right ureteral meatotomy	Fibromuscular tissue	2½ yr.: R.U., 0 Has had no recurrence of pain or urinary symptoms since operation; ureter easily catheterized
Slight difficulty in mounting intramural portion of ureter; good function, no infection, either kidney	K.U.B. negative; bilateral pyeloureterogram normal; pain reproduced on right Cystogram: no reflux	Transurethral prostatic resection	Benign prostatic hypertrophy, chronic prostatitis	3 yr.: Well; R.U., 0; B.C., 500 c.c.; no urinary symptoms or recurrence of pain Urine: No W.B.C., R.B.C., or organisms; ureter presents no obstruction to No. 10 bulb catheter (see Fig. 1 [*A'*, *A"*])
Stylet required in mounting intramural portion of left ureter; good function, no infection, either kidney	K.U.B. negative; bilateral pyeloureterogram normal (Fig. 2*B*) Cystogram: no reflux	Conservative perineal prostatectomy	Benign prostatic hypertrophy, chronic prostatitis	2 yr., 8 mo.: well; R.U., 0; B.C., 550 c.c.; no urinary symptoms or recurrence of pain Urine: no W.B.C., R.B.C., or organisms; Ureter presents no obstruction to No. 10 bulb catheter (see Fig. 1 [*B'*, *B"*])
Marked difficulty in mounting intramural portion of left ureter; no infection in left kidney	K.U.B. negative; left pyeloureterogram, mild dilatation of left ureter (Fig. 2*C*)	Transurethral prostatic resection	Fibromuscular hypertrophy of prostate	1 mo.: patient asymptomatic; R.U., 0; B.C., 400 c.c. Urine: Many W.B.C. and bacilli

TABLE I

CASE NO.	SEX AGE	SYMPTOMS	PHYSICAL EXAMINATION	LABORATORY DATA	CYSTOSCOPIC	
					LOWER TRACT	MIDTRACT
6	61 M	Intermittent aching pain in left iliac fossa for 7 yr.; worse when straining to void Past history: difficult urination for 8 yr.	Tenderness over left ureter Rectal examination: prostate slightly enlarged	Urine: many W.B.C. and bacteria P.S.P. normal	Median lobe prostatic hypertrophy	R.U., 100 c.c.; B.C., 300 c.c.; trabeculation of bladder and a few cellules; hypertrophy of trigone; orifices fine and taut
7	62 M	Attacks of pain over right kidney for 1 yr.; radiation to iliac fossa and right side of scrotum Past history: increasing difficulty of urination for 2 yr.	No tenderness over kidney or ureter Rectal examination: prostate not enlarged	Urine: no W.B.C., R.B.C., or organisms P.S.P. normal	Median fibroglandular bar	R.U., O; B.C., 300 c.c.; trabeculation of bladder; hypertrophy of trigone; urine ejected from orifice with poor force
8	55 M	Severe pain in right iliac fossa, radiating to right lumbar region and right testicle in 5-hr. period; nausea and vomiting Past history nocturia and small urinary stream for 1 yr.	Tenderness over right kidney Rectal examination: prostate slightly enlarged	Urine: no W.B.C., R.B.C., or organisms P.S.P. normal	Broad median bar; slight intraurethral enlargement of lateral lobes of prostate	R.U., 150 c.c.; B.C., 400 c.c.; trabeculation of bladder and early cellule formation; hypertrophy of trigone; taut orifices
9	62 M	Recurrent attacks of pain over left kidney for 2 wk. Past history: nocturia and frequency of urination for 1 yr.	No renal tenderness Rectal examination: prostate not enlarged	Urine: no W.B.C., R.B.C., or organisms P.S.P. normal	Small median bar	R.U., 30 c.c.; B.C., 400 c.c.; hypertrophy of trigone; no trabeculation of bladder

retention of urine in the ureter. During colic this maneuver brings about immediate relief from pain. In one case mounting the intramural portion of the ureter reproduced the patient's pain, and in another distention of the upper tract with skiodan preliminary to taking a pyeloureterogram produced this result.

A plain roentgenogram is an important step in furnishing presumptive evidence in eliminating a ureteral calculus as a cause for the pain. Pyeloureterograms reveal a grossly normal kidney and ureter in most instances, although the early changes of obstruction are occasionally demonstrable in the ureter (Fig. 2). A bilateral dilatation of the ureters was found in one case, although pain had occurred only on one side. A slight unilateral dilatation of the involved ureter was observed in another case and a lengthening of the affected ureter in a third. A clearly demonstrable hydronephrosis was not seen in this series.

—CONT'D

FINDINGS UPPER TRACT	X-RAY FINDINGS	TREATMENT	PATHOLOGIC REPORT	RESULT AND FOLLOW-UP
Moderate difficulty in mounting intramural portion of left ureter; no infection in left kidney	K.U.B. negative; left pyeloureterogram, normal Cystogram: no reflux	Transurethral prostatic resection	Benign prostatic hypertrophy, chronic prostatitis	3 mo.: died on readmission to hospital Diagnosis at necropsy: cirrhosis of liver; no recurrence of pain; frequency of urination and nocturia persisted Urine: many W.B.C., R.B.C., and organisms
Passing No. 8 ureteral catheter up right ureter reproduced pain; good function, no infection, either kidney	K.U.B. negative; intravenous urography normal	Advised to undergo transurethral prostatic resection, but patient refused treatment		6 mo.: patient writes that he still suffers from attacks of right lumbar pain
No difficulty in introducing No. 6 catheter to either renal pelvis, no infection, good function, either kidney	K.U.B. negative; bilateral pyeloureterogram, both ureters dilated; no hydronephrosis	Transurethral prostatic resection	Benign prostatic hypertrophy	4 mo.: patient asymptomatic; no recurrence of pain, R.U., 0 Urine: many W.B.C. and organisms Cystoscopy: trigone much less prominent; trabeculations still present, though fading
Extreme difficulty in mounting intramural portion of left ureter; finally possible with filiform-tipped catheter under spinal anesthesia; good function, no infection either kidney	K.U.B. negative; bilateral pyeloureterogram, lengthening and mild dilatation of left ureter (Fig. 2 *D*)	Patient to undergo transurethral prostatic resection		

Laboratory Tests.—Total and differential tests of renal function made with phenolsulphonephthalein failed to demonstrate any impairment, and specimens of urine obtained from the kidneys yielded no evidence of renal infection by smear or culture.

Diagnosis.—There is nothing distinctive in the type of pain experienced in this syndrome. The diagnosis can be made only on the basis of the urological investigation. The most frequent problem in differential diagnosis is the ruling out of a ureteral calculus which has become obstructed in the intramural portion of the ureter. When such a calculus is not of sufficient size or density to cast a roentgenographic shadow and does not cause bulging of the overlying vesical mucous membrane, the passage of a wax bulb may aid in its detection. Other conditions, such as a ureteral stricture, for example, rarely give rise to confusion.

Treatment and Result.—Removal of the obstruction of the lower urinary tract was found to afford complete relief from pain in all of our patients who underwent treatment. In no instance was there a recurrence following operation, in spite of the fact that some of the patients had suffered from pain for several years. Although the ureteral dilatation which was carried out as a part of the original investigation

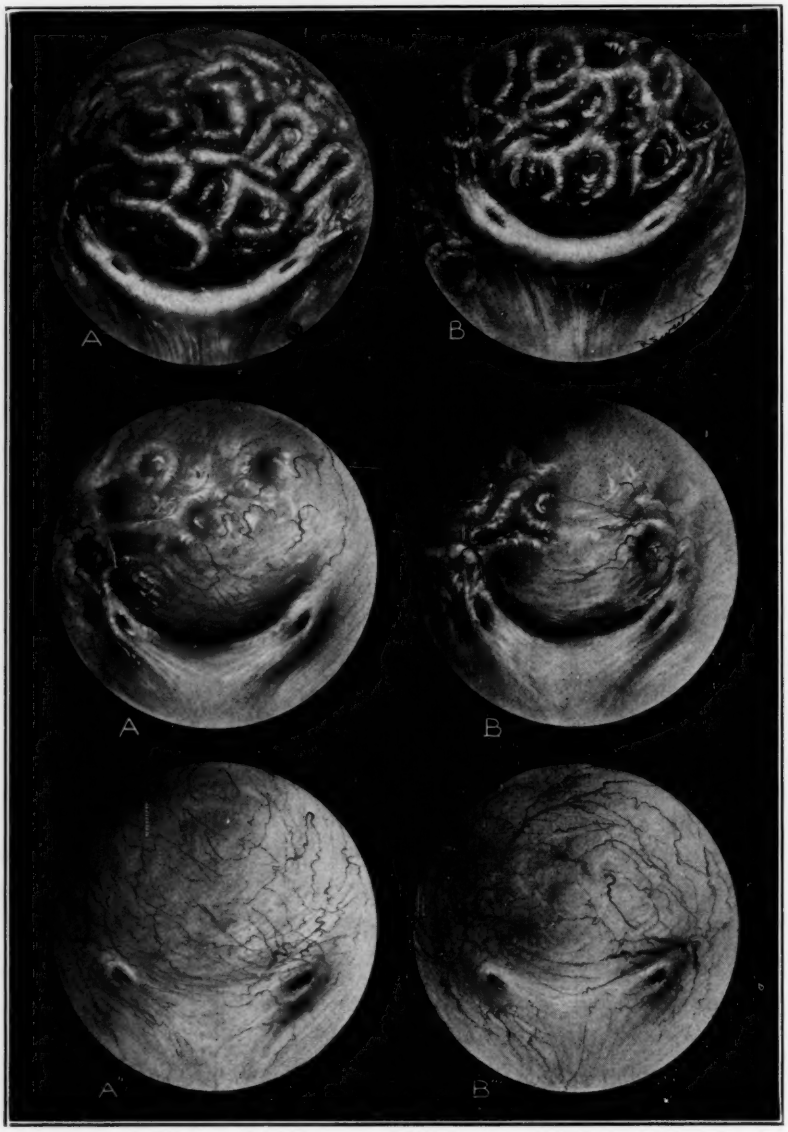

Fig. 1.—Cystoscopic view of the trigone and fundus of the bladder in Cases 3*A* and 4*B*. *A* and *B*, Prior to treatment. Note the pronounced trigonal hypertrophy with the formation of a bas-fond. The ureteral orifices appear as fine, barely perceptible lines. Trabeculations are prominent. *A′* and *B′*, Six months following operation. The trigone has become less prominent and the ureteral orifices appear more relaxed. The trabeculations are fading. *A″* and *B″*, Two years after operation. The trigone and ureteral orifices have resumed their normal appearance. Trabeculations can no longer be seen and there is no further suggestion of a bas-fond.

may have yielded temporary relief, the prolonged freedom from pain, extending up to two and three years, must be attributed to the removal of the primary obstructing factor.

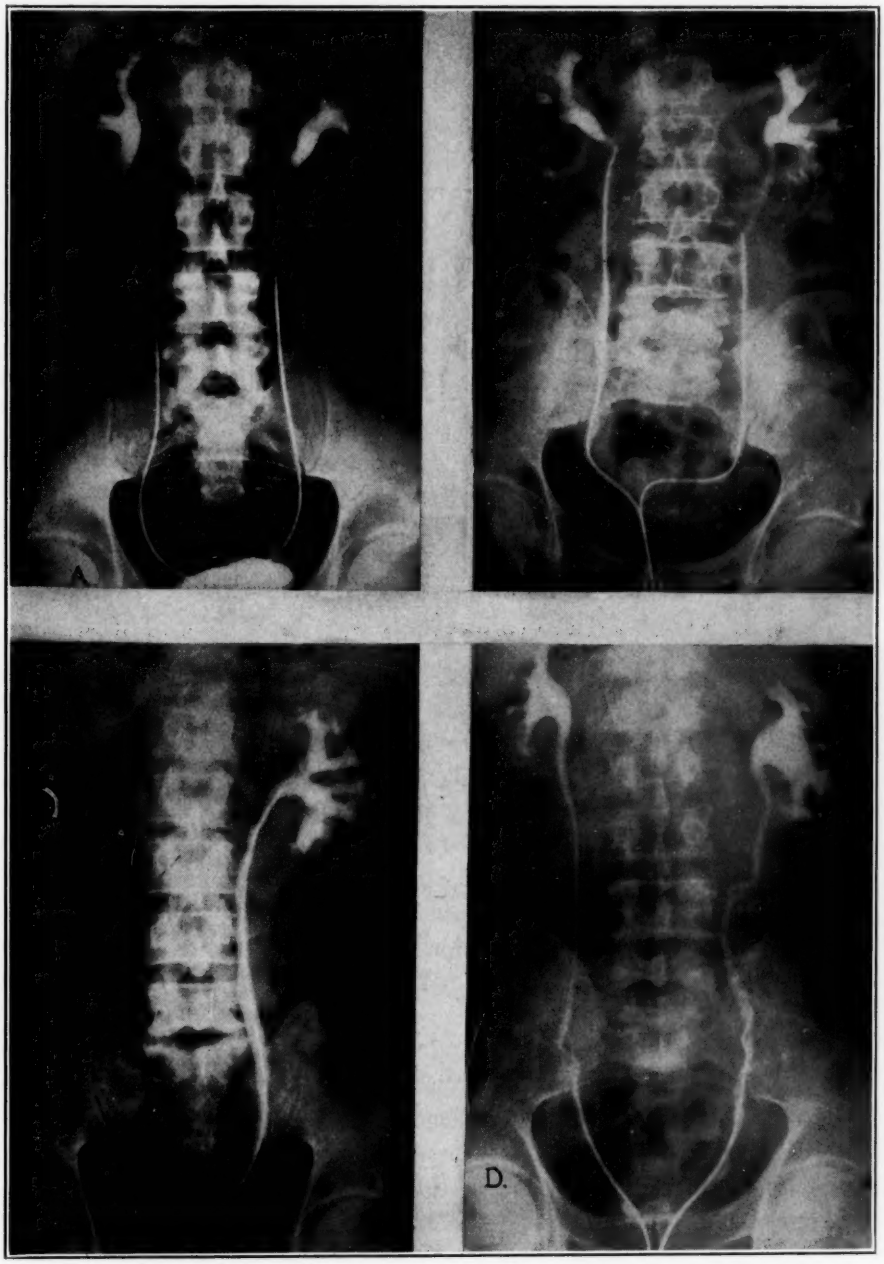

Fig. 2.—Typical pyeloureterograms made at the time of the initial examination. *A*, Case 1. Right renal colic for twenty-four hours. No dilatation of ureter or renal pelvis. *B*, Case 4. Left renal colic for forty-eight hours. No dilatation of ureter or renal pelvis. *C*, Case 5. Left renal colic for three days. Mild dilatation of the ureter above the intramural portion. Note that no skiodan has flowed into the bladder around the catheter. *D*, Case 9. Recurrent attacks of left renal colic for two weeks. Lengthening of the ureter and mild dilatation above the intramural portion.

We now consider ureteral meatotomy, a procedure which we performed for two of our early patients, as a superfluous step which may be fraught with danger. There is the possibility that the edema produced by the meatotomy may cause a temporary occlusion of the ureter and lead to an ascending renal infection. In addition, a too extensive meatotomy may predispose to a vesicoureteral reflux. We also believe that it is inexpedient to resect the interureteral ridge, except in those rare instances in which this structure itself produces an obstruction to the vesical neck.

Immediately after operation, if the removal of the obstruction has been complete, the residual urine will be found to be eliminated and within a period of a few weeks the capacity of the bladder will have returned to normal. As early as a few months following operation we were able to detect, on cystoscopic examination, a recession in the pathophysiologic changes of the bladder and ureter (Fig. 1 *A′* and *B′*). After a still longer period a complete return to normal was observed (Fig. 1 *A″* and *B″*). There was gradual fading and final disappearance of the trabeculations of the bladder. The trigone became less and less prominent as time elapsed. The ureteral orifices lost their taut, stretched-out appearance, became relaxed, and exhibited a normal mobility during the ejection of free spurts of urine. Catheterization of the intramural portion of the ureters offered no further difficulty.

DISCUSSION

In reviewing this series of cases, it will be noted that the common findings were: (1) an early form of obstruction of the vesical neck involving the posterior commissure, (2) hypertrophy of the trigonal and detrusor muscles of the bladder, (3) narrowing of the intramural portion of the affected ureter, and (4) little evidence of functional or anatomical change in the upper urinary tract, although pain referable to the kidney or ureter was the outstanding symptom in every case.

These patients present, therefore, the early stages of a physiologic response on the part of the bladder, the ureter, and the kidney to an obstruction of the lower urinary tract. This occurs during a period before the permanent changes of muscular atrophy and replacement by connective tissue have left their indelible traces in the form of vesical diverticulum, hydroureter, and hydronephrosis. The primary lesion is some form of obstruction of the posterior commissure, the secondary lesion a compression of the intramural portion of the ureter, and the remote effect a distention of the ureter and renal pelvis which gives rise to pain.

It is well known that during mechanical obstructions of the ureter colic occurs only if the renal pelvis or the ureter is suddenly distended. Complete obstruction, of course, is not a prerequisite for pain; a partial narrowing is sufficient to produce sudden distention. As a matter of fact, it is doubtful that complete obstruction of the ureter ever occurs

in uncomplicated obstructions of the vesical neck except for transient intervals. Even in the most advanced cases, urine continues to enter the bladder from the hydronephrotic kidney. That the hydronephrosis and hydroureter arising from an obstruction of the lower urinary tract are so often painless in their development may be attributed to the more common gradual distention, as opposed to sudden distention. Should treatment be delayed in patients who complain of early pain from this source, periodic recurrences may continue, as in two cases of this series; or, following the prodromal seizure, many will develop marked degrees of dilatation of the upper urinary tract without experiencing further pain. Recurrent pain is more likely to be associated with an intermittent obstruction, a recession of pain with a steadily progressive obstruction.

Although there is some divergence of opinion as concerns the exact nature of the ureteral disturbance, most investigators concur in localizing the change to the intramural portion, a contention which is supported by our clinical observations. Examination of the lower portion of the ureter in a specimen which displays advanced hydroureter secondary to prostatic hypertrophy will bear out this view. It will be seen that the widely dilated ureter abruptly gives way to the narrowed intramural segment at the point where it enters the wall of the bladder (Fig. 3).

The narrowing of the intramural portion of the ureter has been variously ascribed to the following factors: (1) hypertrophy of the trigone, (2) hypertrophy of the detrusor, (3) an elevation of the intravesical pressure, and (4) an increased irritability of the vesical and ureteral musculature. A compression of the ureter by the vas deferens, should this latter structure be displaced, in pronounced enlargements of the prostate, need not be considered in these early obstructions.

Tandler and Zuckerkandl observed a close involvement of the lower ends of the ureters in hypertrophy of the trigone, which they readily explained by the connection of the ureteral and trigonal musculature. They found that, in trigonal hypertrophy, the interureteral ridge withstands expansion and maintains the normal distance between the ureteral orifices. This unyielding quality of the intraureteral ridge has a tendency to draw the intramural portion of the ureter into the cavity of the bladder, thereby producing lengthening and narrowing of that segment, as well as a change in its form and obliquity (Fig. 3).

Frontz and Landes first called attention to the association between trigonal hypertrophy and those obstructions of the vesical neck which involve the posterior commissure.* They noted that, although the detrusor undergoes hypertrophy in pure hyperplasia of the lateral lobes, the trigone remains unchanged. They did not consider the pos-

*Frontz and Landes presented these observations as confirmation of the truth of Young's explanation of micturition, that by its contraction the trigone pulls open the floor of the internal sphincter.

sibility that an obstruction of the ureter might have been caused by trigonal hypertrophy, but in our series this was a constant finding. Trigonal hypertrophy was observed in all of our patients and it was invariably secondary to some form of obstruction at the posterior commissure.

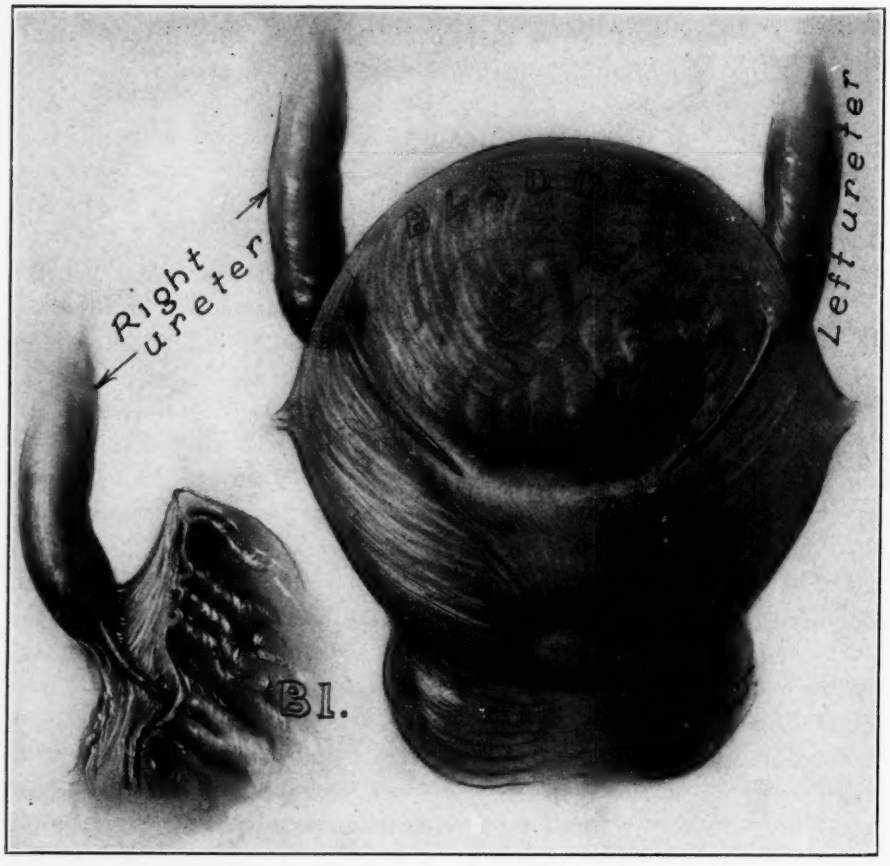

Fig. 3.—Changes in the lower portion of the ureter secondary to marked prostatic hypertrophy. Specimen obtained at necropsy and cleared by Spalteholz technique following injection of ureters with a gelatin suspension of India ink. Note that the widely dilated ureter becomes abruptly constricted at its entrance into the wall of the bladder. There is a lengthening and narrowing of the intramural portion caused, in part, by the marked trigonal hypertrophy which has a tendency to draw the lower portion of the ureter into the cavity of the bladder.

Kretschmer and Hibbs, following a histologic study, concluded that the obstruction of the lower ends of the ureters was caused by hypertrophy of the longitudinal fibers of the muscularis of the ureter. In their opinion these fibers participate in the trigonal hypertrophy which results from obstructive lesions of the vesical neck.

Kreutzmann attributed the difficulty which he encountered in catheterizing the intramural portion of the ureter in cases of prostatic obstruction to hypertrophy of the vesical musculature. Tandler and Zuckerkandl, however, denied that the interlacing fibers of the detrusor ever cause a constriction of the ureter. They felt that the narrowing of

this portion of the ureter is more apparent than real and that, in addition to the changes which they previously described, a compression of the ureter may be accounted for by a valvelike mechanism. As the pressure within the bladder rises, one wall of the intramural portion of the ureter is pressed against the other, even to the extent of producing a flattened "saber-sheath" appearance in long-standing cases.

Hepburn first suggested the possibility of spasm, as a cause of obstruction of the lower end of the ureter, to account for some instances of renal pain. He described this more particularly in bilateral obstructions and especially in the presence of trigonal hypertrophy. Although Hepburn recognized the association between obstruction of the ureter and trigonal hypertrophy, he did not appear to realize the significance of trigonal hypertrophy in obstructions of the vesical neck. Instead, he regarded this spasm as a form of neuromuscular incoordination and consequently treated his patients by ureteral dilatations and division of the interureteral muscle. The relaxation which was obtained under spinal anesthesia in one of our cases, sufficient to permit catheterization of a previously obstructed ureter, is further suggestive evidence of the occurrence of spasticity in some instances.

The infrequent presence of infection of the bladder in our series would seem to exclude inflammation as a primary factor.

Can any explanation other than obstruction of the intramural portion of the ureter be forwarded to account for the renal and ureteral pain in these cases? When colic is initiated by the act of voiding, for example, is there actually a sudden closure of the already narrowed portion of the ureter, as by contraction of the trigone or an increase of the intravesical pressure incident to voiding, or does a vesicoureteral reflux or retroperistalsis of the ureter take place? Although we do not deny that a vesicoureteral reflux occurs under numerous circumstances, we have not observed anything which approaches an abnormal patency of the lower end of the ureter in this early response to obstructions of the vesical neck. A reflux may be observed, certainly, during the late stages of prostatic obstruction when the bladder has become decompensated, as well as in chronic infections of the bladder. In both of these conditions, however, there is a replacement by connective tissue of the vesical and ureteral musculature which predisposes to a reflux as a potential source of pain. Although cystograms in three of our patients gave no evidence of regurgitation, this negative finding does not entirely eliminate the possibility of a reflux, for it is possible that the pressure at which the cystograms were taken did not reduplicate the high intravesical pressure attained spontaneously. Should any type of regurgitation ever take place in this condition, it probably would be in the nature of a retroperistalsis initiated in the irritable muscles of the lower end of the ureter.

We still seek a more exact understanding of the pathologic changes which take place in the intramural portion of the ureter secondary to

obstructions of the lower urinary tract. For such an understanding, it seems necessary first to dispel that confusion which exists concerning its normal anatomy. In spite of the voluminous literature on this subject, we are impressed with the need for a painstaking anatomical study of the relationship between the lower end of the ureter, Waldeyer's sheath, and the trigonal muscle.

SUMMARY AND CONCLUSIONS

Pain which is usually typical of renal colic has been observed in nine cases of early obstruction of the vesical neck. Additional findings were trigonal hypertrophy, early trabeculation of the bladder, difficulty in mounting the intramural portion of the ureter, and little evidence of dilatation of the upper urinary tract.

A study of this problem has led us to conclude that this pain is usually caused by a narrowing of the lower end of the ureter, which results from an obstruction at the posterior commissure. The anatomical relationship between the intramural portion of the ureter, the trigonal muscle, and the detrusor of the bladder is such that hypertrophy of these muscles gives rise to ureteral obstruction. Muscular spasm and an increased intravesical pressure may play important contributing roles, although infection is not a necessary counterpart. The possibility of a vesicoureteral reflux is considered but dismissed as unlikely in these early cases of obstruction.

The recognition of the true cause of the pain is of paramount importance as concerns the institution of proper treatment before any permanent damage has been done. From this point of view the early occurrence of pain is a fortunate danger signal which should not be disregarded.

Following removal of the primary obstruction, the patient is permanently relieved of any further pain and the vesical and ureteral musculatures gradually return to their normal state, giving evidence, thereby, that these early changes are primarily physiologic in nature.

Since obstructions of the lower urinary tract may occur at any age and in either sex, this syndrome should be kept in mind as a possible cause of pain originating in the upper urinary tract, more especially if there has been some difficulty in urination previous to the onset of the colic.

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Editorials

Peritoneoscopy

ALTHOUGH peritoneoscopy was performed for the first time approximately forty years ago, it did not become a popular procedure until recent years. Ruddock has been largely responsible for the widespread awakening of interest in this subject, and, aided by the development of a modern endoscopic instrument, he has developed this method of diagnosis to its present form. An accurate evaluation of peritoneoscopy may need to await the lapse of further time, although certain current impressions regarding it seem to be evolving as facts. With the initial wave of enthusiasm that followed the revival of this procedure, reports in the literature have emphasized for the most part only its advantages. It would appear that the limitations and contraindications of this procedure should not go without mention.

Peritoneoscopy may be a very useful procedure in selected cases. When accurate diagnosis of chronic intra-abdominal disease, especially that associated with ascites, is difficult or impossible by the use of ordinary methods of clinical investigation, peritoneoscopic inspection of the abdominal cavity may be the means of establishing the diagnosis in a simple manner and beyond doubt. Removal of a significant biopsy specimen through the peritoneoscope, which should always be performed when feasible, affords irrefutable diagnostic evidence. The risk is slight, discomfort to the patient is minimal, and the necessary period of hospitalization is short. Pentothal sodium intravenously administered provides a more pleasant anesthesia for the patient than local infiltration of the abdominal wall with procaine hydrochloride (novocain). The two conditions in which peritoneoscopy may be helpful most frequently are intra-abdominal malignancy and cirrhosis of the liver when these diagnoses cannot be established with certainty by any other method except exploratory laparotomy. Various other lesions may be diagnosed less frequently.

It seems important that the limitations of peritoneoscopy should be appreciated as clearly as its merits. It appears definite that peritoneoscopy will never replace exploratory laparotomy, although in a relatively small, selected group of cases it may render operation unnecessary. Great significance usually cannot be attached to findings of negative significance on peritoneoscopic examination, as obviously only the surface of certain intra-abdominal viscera can be visualized and even the surface of many structures cannot be seen. In this regard, peritoneoscopy is similar to bronchoscopy and is in contrast with cystoscopy.

In the case of bronchoscopy, only a very limited portion of the pulmonary system can be visualized with the result that this examination can exclude disease with certainty in only a limited region. Only when an organic lesion is grossly evident within the abdominal cavity can peritoneoscopy be expected to establish an accurate diagnosis.

It has been stated that peritoneoscopy may be employed to determine the operability of certain malignant lesions; for example, carcinoma of the stomach. If, in these cases, the decision as to operability is based on the presence of metastatic lesions, this practice may be sound; however, when this decision is based solely on the local extent of the primary lesion, the use of peritoneoscopy for this purpose seems definitely unwise. One need not operate many times for gastric carcinoma in order to appreciate how difficult a decision in regard to operability may be, even when the abdomen is open and the lesion is in the surgeon's hand. Even large, high-lying lesions which have invaded the gastrohepatic or gastrocolic omentum may be completely removed at times with a reasonable hope of cure. In contrast, certain smaller lesions which have penetrated into the pancreas are actually inoperable. This fact could not possibly be detected by means of the peritoneoscope. Any method which is accepted as capable of supplying criteria in regard to the operability or inoperability of malignant lesions should be as infallible as is possible, for an operable lesion which is erroneously considered to be inoperable may be responsible for a direct loss of life. It appears probable that the experienced roentgenologist is able to offer as accurate an opinion as, or even a more accurate opinion than, the peritoneoscopist regarding the operability of gastric carcinoma, based on the local extent of the lesion, and it is well known that the roentgenologist may occasionally be in error in this regard.

The use of peritoneoscopy in the presence of possible acute inflammatory conditions within the abdomen has been repeatedly and rightly condemned. Previous abdominal operations usually render a satisfactory peritoneoscopic examination impossible because of adhesions. Infants and small children cannot be examined with the same degree of satisfaction as adults. Diagnosis made on the basis of inspection of the gross lesion alone, peritoneoscopically, without a biopsy, may be in error to the same extent that the diagnosis of any lesion on the basis of inspection of the gross specimen alone may be unreliable. Dangers of the procedure are few, but perforation of a viscus, severe hemorrhage, and spread of intra-abdominal infection have been known to occur. It seems desirable that peritoneoscopy should be performed by a surgeon rather than by a bronchoscopist, urologist, or internist. The surgeon is most familiar with the appearance of the abdominal viscera in health and disease. If an accident should occur, the surgeon may proceed at once as the condition requires and, if the examination indicates the desirability of exploration, this may be carried out without delay. Although

peritoneoscopy is a useful and valuable procedure under proper circumstances, undue enthusiasm and unwarranted indications for its use should be avoided. Likewise, too great acceptance of its reliability in certain types of cases should be curtailed.

—*James T. Priestley, M.D.*
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Morphine and Peritonitis

DURING the past several years, much has been published regarding the treatment of appendicitis. New concepts of origin and development have been advanced and old ideas of treatment have been revived and re-examined in the effort to reduce mortality and morbidity. Out of the mass of reported material, the principles of Murphy and Ochsner have again taken distinct form.

At present there are two well-defined, opposed groups; one advocating immediate surgery in all stages of appendicitis, the other counseling delay and nonsurgical methods in the presence of abscess or spreading peritonitis. Each group presents formidable series in support of their respective views, almost forcing the conclusion that both are correct. Examination of the evidence, however, suggests the possibility that the position of either faction is not invulnerable. Reports of cases operated upon indicate that extensive and intractable peritonitis may not occur as often as the proponents of delay believe. On the other hand, the adherents to Ochsner's principles present quite satisfactory evidence that, in the presence of extensive spreading peritonitis, surgery is of little value and is at times harmful. What variance of opinion there is appears to rest upon the diagnosis of the degree and extent of peritonitis which may attend any case of appendicitis. In fact, if this one variable factor could be removed by more accurate study and estimate, it is probable that much of the present conflict would disappear. There is no question but that the usual methods and means are sufficient to identify the presence of appendicitis, but recognition of peritonitis and its extent and degree is still difficult. If this is the situation and if this is the issue, it seems reasonable that every means be recruited and examined to make better diagnosis possible.

Steinberg[4] has recently presented a method of examination of peritoneal exudate which may serve as a basis, if correlated with other clinical findings. Even though it may prove to be of little immediate value, it may be of considerable worth as a basis for classification of statistical data. There is one other clinical method of approach which has been generally overlooked and which, because of its safety and ease of application, deserves further trial. That is the use of mor-

phine. Its use as a diagnostic agent has been reported from various sources,[1-3, 5] but its promise of usefulness has not been thoroughly tested. Morphine has long been decried as a source of confusion and danger to patients with acute abdominal disease. However, better knowledge of its action and a definite plan for its use make this teaching no longer sound. If, after careful preliminary inquiry and physical examination, morphine be administered in sufficient dosage to abolish pain, the cerebral component of the abdominal muscle spasm will be removed and re-examination will disclose with much greater accuracy the extent and degree of peritoneal involvement. As such evidence is of prime importance in diagnosis and is essential in determining the type of treatment, it would appear that a method which makes this more easily available merits consideration.

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—*Arthur A. Zierold, M.D.*

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Erratum

On page 925 of the December, 1939, issue, in the article by Ochsner, DeBakey, and Murray entitled "Absence of the Anterior Mediastinum With Report of Case Associated With Congenital Diaphragmatic Hernia" the last sentence in the first paragraph should read: "'Since, in the dog, the normal history of the pleural expansion is an interruption of the process at a point just short of dissolution of the anterior mediastinum, it is not improbable that *unstable* development, whether in a dog or human fetus, might lead to complete disappearance of the mediastinal septum.'"

Recent Advances in Surgery

CONDUCTED BY ALFRED BLALOCK, M.D.

THE SURGICAL TREATMENT OF TUMORS OF THE STOMACH

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CARCINOMA of the stomach today accounts for one-fifth of the annual mortality from carcinoma in the United States.[23] By the time the diagnosis is made, resection can be carried out on only twenty-five of every one hundred victims of the disease, and of these only five have a reasonable chance of living five years.[36] While this figure, alarming as it is, holds for the disease as a whole, once resection is justifiable, the chances of five-year survival increase to 20 to 50 per cent.[44]

DIAGNOSIS

There is no train of symptoms or signs characteristic of gastric carcinoma. Occasionally marked secondary anemia, the result of progressive bleeding, is the only presenting symptom. Indigestion, anorexia, pain, vomiting, and weight loss are usually present and are reported in this order of frequency by Marshall and Taylor after an analysis of 291 cases. But, by the time most of these symptoms are apparent, the patient has frequently passed the point at which surgical removal of the lesion is feasible. Rivers and Dry point out that, except for pyloric lesions which cause early obstruction, it is the complications and systemic effects of the carcinoma which produce the symptoms. By this time the lesion has advanced beyond the bounds of operability. Nor does the duration of symptoms offer aid to diagnosis. In his series Morley reports the average duration of symptoms prior to operation to be 12.7 months for gastric carcinoma as compared to 10.3 years for gastric ulcer. Lahey, Swinton, and Peelen find the duration of symptoms to be 8.1 months for operable cases and 8.5 months for inoperable. Bull reports that 20.2 per cent of the inoperable cases had clinical symptoms for only 1 to 5 months. In spite of these obstacles, early diagnosis is occurring with greater frequency, according to MacCarty; he, as a pathologist, finds a greater number of small malignant lesions and reports that in 9.7 per cent of 410 specimens the malignant ulceration was the size of a quarter or smaller.

Gastric carcinoma appears most frequently in those in the fifth and sixth decades of life.[27] However, there are isolated reports, growing in number annually, of proved carcinoma of the stomach in

younger patients. For example, MacFarland describes its occurrence in a girl 21 years of age; Patterson and Gross, in a man 27 years of age. Almost any large series will include a few cases of carcinoma of the stomach in patients below the age of 30 years.

There is a definitely higher occurrence of gastric cancer in males than in females, the ratio being slightly more than three to one.[27] Dublin also points this out and estimates that carcinoma of the stomach is responsible for about one-third of all deaths from carcinoma in white males and one-fifth in white females.

It is widely believed that patients with carcinoma of the stomach have an achlorhydria, but this is unreliable. Comfort and Vanzant find the incidence of achlorhydria in cases of carcinoma of the stomach to be three times the normal. However, the range of acidity for men with carcinoma of the stomach varies from 0 to 90, which is only ten points short of the range for normal men. Comfort, Butsch, and Eusterman, in studying the gastric analyses of 79 patients of all ages who developed carcinoma of the stomach during an average period of observation of six years, discovered that the percentage of achlorhydria increased from 38 to 64.6 per cent. They believe that chronic gastritis as well as the tumor may be responsible for the frequent depression of gastric secretion after the development of gastric carcinoma. Robertson reports two cases in which there was a gradual disappearance of free hydrochloric acid during the entire period of observation, which, he believes, is the result of an intractable gastritis, secondary to the development of pyloric stenosis from the neoplasm. Shay and Schloss, in discussing the differential diagnosis of carcinoma and ulcer, call attention to the fact that in the case of ulcer there should be no drop in the gastric acidity in gastric analysis at three-week intervals, and that the occult blood reaction should disappear in the test meal. Great stress is placed on the disappearance of occult blood, since other improvements may occur with a malignant as well as a benign lesion. Apparently in early cases in which the diagnosis is questionable, a progressive lowering of the gastric acidity may be considered highly suggestive of carcinoma. On the other hand, Comfort and Butsch point out that the presence of any single laboratory or clinical finding does not justify an absolute diagnosis of cancer or benign ulcer if the diameter of the lesion is less than 4 cm.

The disclosure of a malignant lesion of the stomach by x-ray has reached such a high degree of efficiency that in competent hands a correct diagnosis may be made in 90 per cent of the cases.[53] X-ray studies, therefore, have become a prerequisite to diagnosis in any patient over 40 years of age having indigestion, dyspepsia, or mild epigastric distress which does not respond immediately to medical treatment.[43] In practice, it may often be difficult for the physician to convince his patient of the importance of thorough and usually rather

expensive x-ray studies for what seems a trivial complaint. But the physician must be alert to the danger and insistent upon accurate diagnosis if gastric carcinoma is to be discovered early at a resectable stage. In those instances when the roentgenologist is not certain whether the lesion is malignant or benign, it is customary for him to call it to the attention of the clinician and to request re-examination after a three-week interval of strict medical treatment.

Schindler and Gold report ten cases showing the value of gastroscopy in making an early diagnosis of gastric carcinoma. They believe that close cooperation between the gastroscopist and roentgenologist is essential in the routine periodic examination of patients with precancerous states, especially when the roentgen-ray results are negative or doubtful.

Relationship of Gastric Ulcer to Malignancy.—The question of whether or not a gastric ulcer undergoes malignant degeneration continues to be a moot point. Miller emphasizes the fact that the clinician should never forget that any ulcer of the stomach may be carcinoma and that it should be watched closely. Ransom quotes as the consensus of present-day opinion that about 5 per cent of benign ulcers undergo malignant degeneration if they resist treatment by dietary and other nonsurgical measures; Wulff believes that carcinoma arises from an ulcer in about 2.1 per cent of all cases. Scott and Mider state that most ulcers of the stomach over 2.5 cm. in diameter are malignant and that those smaller than 1.5 cm. are probably benign, but this observation is almost valueless as a guide to therapy in the individual case.

After three weeks of rigid medical treatment, Scott and Mider also divide all gastric ulcers into an ulcer and a carcinoma-suspect group. If the lesion is a benign ulcer, the pain should diminish the first week; all symptoms and occult blood should disappear in two weeks; and the size of the ulcer should decrease one-third of its area within three weeks. When any one of these three criteria is not fulfilled, the ulcer is placed in the carcinoma-suspect group, and surgery is advised. It is true that a few benign ulcers which are resistant to medical treatment because of adherence to the pancreas or liver will fall into this carcinoma-suspect group, and it is also true that the symptoms of malignant ulcer may be alleviated by medical treatment. Therefore, x-ray studies must be repeated every four to six weeks, if surgery is not performed, until all evidence of the ulcer has disappeared. If there is any recurrence of symptoms while the patient is under treatment, if the ulcer does not progress toward healing, or if it increases in size, operation should be advised.

Prepyloric gastric ulcers, as pointed out by Holmes and Hampton, are particularly likely to be malignant, although there is a controversy about the exact incidence.[83] Morley finds that 12 per cent of chronic

ulcers and 66 per cent of gastric carcinomas occur in the prepyloric region. Singleton[82] believes that any annular deformity in the pyloric region may well be considered malignant and that any ulcer within 2.5 cm. of the sphincter should be seriously regarded. However, in studying a series of 145 consecutive gastric ulcers in the terminal inch of stomach exclusive of the pyloric sphincter, he found the lesion was benign twice as frequently as it was malignant.[83] Sampson and Sosman, of the Peter Bent Brigham Hospital Roentgenological Department, find that 75 per cent of chronic ulcers in the prepyloric inch of the stomach are cancerous. It is now generally believed that ulcers in the prepyloric region should be considered malignant or potentially malignant, and should be subjected to strict medical treatment and repeated x-ray examinations over a prolonged period if immediate surgery is not carried out.

It is generally accepted that ulceration along the greater curvature is almost invariably malignant, regardless of size or location.

All gastric ulcers, therefore, should be considered potentially malignant and patients harboring such a lesion should be kept under close medical treatment augmented by repeated x-ray examinations, gastric analyses, and examinations of gastric contents and stools for occult blood. If the lesion does not respond to treatment within a period of three weeks, surgery is advocated.

OPERABILITY

The patient with gastric cancer should be given the benefit of an exploration, regardless of the apparent size of the neoplasm by physical examination and x-ray, unless there is clear and unmistakable evidence of metastasis. A rectal examination to determine the presence of implantation in the pouch of Douglas should be done routinely. In addition, Allen[3] emphasizes that an inspection of the anteroposterior view of the stomach filled with barium may give some clue as to whether or not there is metastasis, particularly in the region of the liver. If the stomach is normal in position, mostly to the left of the midline, it can be assumed that there is no extensive metastasis, at least in the region of the gastrohepatic ligament. Should the stomach lie mainly to the left of the vertebral column, extirpation of the organ is more feasible, since, when the stomach is drawn to the right, there is probably tumor in the gastrohepatic omentum. If there appears to be generalized metastasis, a needless exploration may be avoided by peritoneoscopy. Pack and Livingston point out that inoperability or curability is definitely evident on peritoneoscopy.

Finsterer believes that the only patients inoperable are those in whom there are distant metastases which can be definitely demonstrated, and that large palpable tumors, advanced age, severe cardiac or pulmonary disease, secondary anemia, or advanced cachexia should

not contraindicate operation. Walters[91] remarks that, regardless of the apparent extent of the malignant lesion as shown by x-ray, 15 to 20 per cent of the cases reported to be inoperable or on the border line, have sufficient stomach to permit a resection. Balfour[6] notes that the result for large tumors which at first appeared impractical of removal was a survival rate at the end of seven years of 33 per cent, as compared to 24 per cent for small tumors. Size alone, therefore, is not necessarily a deterrent to exploration and successful resection.

Bony metastasis from carcinoma of the stomach may be more common than supposed, according to Lawton, who suspected metastasis to the bone in 10 of 606 patients with carcinoma of the stomach. In 3, metastatic lesions of the bone were found at autopsy, despite negative x-rays. He concludes that the diagnosis must rest on clinical symptoms alone, because it is not always possible to confirm it by roentgenologic examination. Metastasis to the lungs is so uncommon that routine x-ray of the chest, other than the usual fluoroscopic examination at the time of the gastrointestinal series, is usually unnecessary.

The operability of carcinoma of the stomach varies markedly in urban and rural districts, being much higher usually in surgical centers.[44] MacGuire finds that 50 per cent of the clinical admissions for gastric cancer are operable; Marti, 55.8 per cent of 299 cases; St. John, Whipple, and Raiford find 13.6 per cent of 718 cases; Lewisohn and Mage, 14.3 per cent; and in 1935 Lahey, Swinton, and Peelen, 22.1 per cent which increased to 26.1 per cent in 1938.[52] Bull was able to perform radical operation in 23.3 per cent of the men and 30 per cent of the women with carcinoma of the stomach. Parsons and Welch report an increase in resectability during the past ten years of from 27 to 37 per cent. Livingston and Pack, in an analytical study and statistical survey of sixty years of surgical treatment of gastric cancer, conclude that from two-thirds to three-quarters of the lesions are unresectable when first seen. Marshall,[52] who submits all patients with gastric carcinoma to surgery unless there is evidence of widespread metastasis, such as to supraclavicular glands and to the pouch of Douglas, reports that 26 per cent of his patients with carcinoma of the stomach had operable lesions when the tumor was diagnosed. Maingot[49] believes that less than 30 per cent of the patients with cancer of the pyloric segment of the stomach can be subjected to radical resection. Balfour[5] reports an operability rate of 45 per cent for those cases in which exploration was carried out.

From all these reports it is apparent that only about one case in five comes to surgery early enough to warrant radical resection. This disheartening state of affairs serves to re-emphasize the importance of early, thorough investigation of every case of upper gastrointestinal distress.

PREOPERATIVE PREPARATION

The patient with gastric cancer is usually not a good surgical risk because of one or more complicating factors, such as anemia, malnutrition, or dehydration. There is also the danger of infection from soiling of the operative field from gastric contents, usually highly infectious, and of postoperative pulmonary complications. Attention to details in the preparation of the patient coming to operation is essential and has done much to lower the postoperative mortality.[69]

In addition to the routine laboratory studies on blood and urine, determinations should be made of the serum protein, vitamin C, and kidney function. Gastric analysis should always be done to determine the presence or absence of free hydrochloric acid, regardless of how obvious the diagnosis is. Every patient with gastric carcinoma should be typed, and there should be blood available for transfusion.[20] If the hemoglobin is below 40 per cent, a preoperative transfusion should be given.[27] Transfusion must also be given if the serum protein level is low. Under no circumstances should a patient with a low protein level be subjected to gastrointestinal anastomosis, because edema of the gastric wall not only may interfere with the anastomosis, but may cause a nonfunctioning stoma.[57, 69]

The patient with pyloric obstruction is placed on constant gastric suction and is encouraged to drink large amounts of water to wash out the stomach thoroughly. In such instances, it is obviously necessary to watch the blood chloride level and to maintain electrolytic balance by intravenous administration of 5 per cent dextrose in isotonic saline solution. If the patient receives sufficient fluid by mouth to insure a urinary output of at least 1,000 c.c. daily, no intravenous administration of fluid is required. However, in the presence of obstruction 5 per cent dextrose in isotonic saline solution or sterile water should be given in sufficient amounts, usually 2,000 to 3,000 c.c. per day, to insure a satisfactory urinary output.[27] If edema of the extremities develops, there is probably either a lowered total serum protein or an excess of chlorides. Therefore, in such instances immediate determination of the blood chlorides and serum proteins should be made. A transfusion may be indicated, or distilled water may be substituted for the saline solution, depending upon the laboratory findings.

If the patient does not have gastric retention, the stomach should be thoroughly washed out daily, starting several days before operation, to make certain that all coarse particles of food have been removed.[27] During this time the patient should be maintained on a high caloric, high vitamin diet.[21] Vitamin C, which is necessary for proper wound healing, may be supplied in adequate amounts by giving the patient orange juice with the addition of cevitamic acid.[3]

Gastric lavage should be repeated the night before operation and the following morning.[20] In addition, as pointed out by Horsley, it is advisable to attempt to sterilize the gastric contents by the administration of dilute hydrochloric acid, unless there is ample free hydrochloric acid present by gastric analysis. Gastric lavage with 0.25 to 0.5 per cent hydrochloric acid should be carried out several times during the twenty-four hours previous to operation. Hydrochloric acid, when sweetened to make it more palatable, may be given by mouth. This attempt at decreasing the bacteria count of the stomach is now widely used because peritonitis is one of the main causes of death following resection for gastric carcinoma.[30] When a culture of the gastric contents shows beta-hemolytic streptococci, Parsons and Welch state that sulfanilamide may be tried. While these methods may be of value, thorough mechanical cleansing of the stomach by gastric lavage is the most useful procedure. A small Levine tube may be left in place through the nose to maintain constant gastric suction during the operation and the immediate postoperative period.

In poor-risk patients with a high degree of pyloric obstruction and marked changes in blood chemistry, it may be judicious to perform a jejunostomy for feeding purposes.[25] After several weeks of jejunal feeding, the condition of the patient may improve sufficiently so that gastric resection may be contemplated with a moderate degree of safety.

Since pulmonary complications, along with peritonitis and infection, are one of the common causes of death following resection for gastric carcinoma, patients must not be subjected to surgery under any circumstances if there is evidence of respiratory infection.[20]

ANESTHESIA

There is no general agreement as to the choice of anesthesia; in fact, comparative mortality rates are reported for all types of anesthesia. Avertin (70 to 80 mg.) supplemented by ethylene or 1 per cent novocain infiltration is recommended by Meyer. However, Parsons and Welch state that avertin as a basal anesthesia has been found unsatisfactory, for it does not give as complete relaxation and results in more frequent postoperative complications. Finsterer prefers local novocain anesthesia with splanchnic block, because, he states, by its use the mortality from pneumonia in his cases is only 1 per cent. Lahey, Swinton, and Peelen in 1935 advocated the use of intratracheal ethylene or cyclopropane with regional field block with metycaine; but in a more recent article[37] announce a return to the use of spinal anesthesia, which they feel can be trusted to provide complete anesthesia and relaxation for at least three hours. Sise emphasizes that in most instances spinal anesthesia with pontocaine or nupercaine is quite satisfactory, but an anesthetist well-skilled in its administration and management is essential. If the opera-

tion is started with a general anesthetic, Allen[3] advises intratracheal administration with a closed machine. Especially for high resection, an intratracheal administration of anesthesia is recommended because it prevents regurgitation of the gastric contents into the bronchial tree during manipulation of the stomach at the time of operation. In addition, as pointed out by Pack and Livingston, hyperventilation of the lungs is also possible and is advantageous when reflex muscular inhibition, pressure on the thorax, or severance of costal cartilages has depressed respirations.

The majority of surgeons seem to use the type of anesthesia to which they are most accustomed and which existing facilities permit, resorting to intratracheal anesthesia usually, if a high or total resection is anticipated.

INCISION

The location of the incision may be varied, depending upon the site and extent of the lesion. A midline incision, or one just to the left of the midline, is most frequently used. Balfour[6] recommends making a small initial peritoneal opening so that if peritoneal implants are found the small wound may be closed immediately, thereby enabling the patient to be out of bed in a few days. This would appear to be an important point, since the percentage of cases having extensive metastasis is considerable. If it is apparent that a high resection will be necessary, a left rectus incision which can be extended well above the costal margin is preferred. Division of the costal cartilages or side extensions of the incision to the left are rarely necessary.

CHOICE OF OPERATIONS

After the abdomen is opened and no metastasis is apparent, the pouch of Douglas is first explored to see if there is seeding in the pelvis or cul-de-sac. A thorough exploration then follows.

The general abdominal examination must be thorough because it is not uncommon to encounter two or even more primary tumors in the same patient. While pathologists find this frequently, the clinical finding of two separate, distinct, and simultaneous carcinomas is rare. Pemberton and Waugh have reported the recovery to active life of a 57-year-old physician after the removal of primary carcinomas of the sigmoid and stomach. Maingot[50] has described a similar case in which primary tumors of the stomach and sigmoid were removed at one operation, with uneventful recovery of the 55-year-old female.

In addition to determining distant metastasis, the surgeon must also carefully palpate the omentum and the glands about each curvature to determine the extent of lymphatic extension. He should not be discouraged upon finding numerous enlarged nodes, because many of these may be the seat of chronic inflammation rather than tumor. Balfour[6] states that unless the enlarged lymph nodes beyond the range of removal

are proved malignant and there is other evidence of distant metastasis, it can be assumed that they are only inflammatory and that resection may be carried out.

The surface of the liver is visualized and palpated. The region of the gastrohepatic ligament and great omentum is similarly inspected for evidence of metastasis. Hunt[31] states that, as far as the stomach was concerned, 43 per cent of his cases were operable but that metastasis to the liver, extensive involvement of the lymph nodes along the lesser curvature and gastrohepatic ligament, or multiple remote peritoneal transplants ruled out the possibility of resection.

Regardless of how obvious the diagnosis may appear, a gland or portion of a metastatic nodule must be obtained for microscopic examination as proof that the lesion is not benign. The lesion may prove to be lymphoma which, unlike adenocarcinoma, is highly radiosensitive.

The amount of fixation of the neoplasm, as well as its extent, is then carefully determined. When there is diffuse metastasis and when free fluid is present in the abdomen, further procedures are of questionable value unless there is a high degree of pyloric obstruction. Even then, Balfour[6] states that gastroenterostomy is likely to prove disappointing in relieving the obstruction.

Palliative Operations.—A small metastasis to the liver or a single implant on the rectal shelf does not necessarily contraindicate palliative gastrectomy. If it is decided from a thorough abdominal examination that a radical resection is not to be done, the problem arises as to what type of palliative procedure, if any, is justifiable.

A gastroenterostomy may be done to relieve pyloric obstruction and to make the terminal months more bearable. In such instances Finsterer performs an anterior gastroenterostomy with enteroanastomosis, because marginal ulceration is a rare complication in cases of carcinoma of the stomach. Balfour[6] prefers the Devine exclusion operation as a palliative procedure for it affords complete relief from actual or impending obstruction and results in a very definite prolongation of life in comfort, while gastroenterostomy does not increase the average expectancy of life more than one month over exploration alone. Maingot[49] prefers the Devine exclusion operation for the inoperable case because the survival period is increased, probably due to the persistence of a wide-open stoma. Occasionally the excluded segment can be removed later at a second operation.

Pack and Scharnagel[65] advocate a two-stage operation, the first stage of which consists in exclusion of the carcinomatous segment of the pylorus and antrum and gastroenterostomy under local anesthesia. The patient is built up by a liberal postoperative diet to tolerate better the second stage. After the inflammatory reaction about the tumor has subsided, a partial gastrectomy is carried out. This procedure is followed

even in the presence of metastasis to the liver or supraclavicular nodes when the patient is in good condition and the stomach is sufficiently mobile.

Maes advocates the Eiselsberg-Witzel technique of creating a watertight permanent fistula to the jejunum for inoperable obstructive carcinoma of the stomach. Following this, frequent small feedings are given at the same rate that food would pass from the stomach into the intestinal tract in the normal process of digestion.

Any of these procedures carries a definite mortality. As the figures of Parsons and Welch show, in their series there was a postoperative mortality of 15.5 per cent for exploratory laparotomy and of 25 per cent for gastroenterostomy. Lahey, Swinton, and Peelen report a 6 per cent mortality following exploration, and a 40 per cent mortality following palliative operations. Livingston and Pack point out that the operative mortality for gastroenterostomy is as great as for attempted resection, yet the average extension of life is not more than two months. Balfour[5] finds that the duration of life for a group of patients having exploration only was five months; when gastroenterostomy was performed, the postoperative mortality was 11 per cent and only one more month, on an average, was added to the life expectancy. Anschutz hesitates to perform a palliative operation for gastric carcinoma, because the average length of life after operation in the 190 cases, he reports, was but six months.

It would appear that, in the presence of advanced carcinoma, short-circuiting procedures add little to the span of life. However, when the short-circuiting procedures are combined with the Devine exclusion type of operation, a longer period of survival may be expected.

Subtotal Resection.—If, after a thorough pelvic and abdominal exploration with careful examination of the liver, it is apparent that there is limited, or no, metastasis and that the mass is movable and can be resected, the surgeon must then determine the type of resection to be carried out. In order to insure complete removal of the growth, he must not have a fixed idea as to the type of surgical procedure he intends to perform, but must vary it with the individual case and the extent of the lesion found at exploration. This is a great tax on surgical judgment. In many instances in which the lesion might be considered inoperable by others, the surgeon of wide experience in gastric surgery is able to carry out successful resection.

Recent microscopic studies more clearly define the limits about the neoplasm where the gastric or duodenal wall should be divided to insure a resected margin free of tumor-cell involvement. Ruggieri, in studying the cardiac segment of the gastric wall in 19 instances, found cancer cells in the layers of gastric wall as far as 7 cm. from the macroscopic periphery of the tumor, and pathologic alterations of the tissue of the wall as far away as 9 or 10 cm. He, therefore, advo-

cates a wide resection. With this in mind, it is probably desirable for the surgeon to include in the resection at least 10 cm., or almost a hand's breadth, of normal appearing gastric wall above the neoplasm. Verbrugghen, after studying 50 resected specimens, comes to the conclusion that in gastric carcinoma at least 4 cm. of healthy gastric wall should be allowed from the edge of the ulcer along the lesser curvature toward the cardia in order that the resection may include the whole primary focus.

Castleman reports 21 cases of carcinoma of the pyloric end of the stomach in which there was extension of the tumor into the duodenum, varying from 4 to 23 mm. In most surgical specimens cancer cells were found at the distal cut edge, implying that the remaining duodenal tissue contained tumor. The lesion rarely involves the mucosa but spreads along the submucosa often in the lymphatics. He suggests that at least 3 cm. of duodenum should be removed in all gastric resections for carcinoma of the pylorus. Since it has been accepted for years that carcinoma of the stomach does not extend into the duodenum, surgeons perhaps are not particularly careful about how close to the neoplasm resection is carried out on the duodenal side. Usually, however, the crushing clamps customarily applied before dividing the duodenum will include at least 1 to 2 cm. of duodenal wall beyond the limits of the surgical specimen.

In addition to removing the tumor well beyond its normal limits and including a portion of the duodenum as well in lesions of the pylorus, many surgeons are recommending a complete excision of the omentum, which can be accomplished with little technical difficulty. Removal of the omentum, it is believed, will decrease the chance of leaving any metastatic tumor tissue. With these factors in mind, the surgeon must determine from the location and size of the tumor the extent of resection and the procedure most feasible to execute. The limits of safety should never be reduced in order to leave sufficient gastric wall to effect a preconceived plan of anastomosis.

Recently Pack and Livingston have thoroughly reviewed the various types of resection for gastric carcinoma. Some form of the Billroth II operation, either the Polya or Finsterer-Hoffmeister, is usually recommended over the Billroth I. However, the Billroth I type seems to meet a definite need in small neoplasms of the prepyloric region. In such instances a sufficiently wide resection may be carried out to permit gastroduodenostomy by the Billroth I method. Marti reports a mortality of 3.8 per cent in 26 cases of resection for carcinoma by the Billroth I method, in comparison with a mortality of 21.5 per cent of 130 cases resected according to the Billroth II technique. However, the instances in which he used the Billroth I technique were small, deep-seated carcinomas, so that a comparison of the two procedures should not be made on the basis of these figures. From his

statistics it would seem that for small lesions in the pyloric region of the stomach a Billroth I operation carries a definitely lower mortality rate. Cattell and Colcock feel that the Billroth I procedure is well adapted to cases of prepyloric malignant ulcer or cancer involving less than one-half the corpus of the stomach. It may well be the operation of choice in the elderly or poor-risk patient where the hazards of the operation may be in direct relation to the length of operation, shock, and widespread soiling. In addition, Marshall[52] believes that this operation is capable of readier and more rapid completion than a modification of the Polya operation and that the entire operation can be done above the transverse colon without gross contamination, an important factor in the elderly, poor-risk patient.

Pack and Scharnagel,[67] while admitting that the Billroth I operation has advantages in the treatment of malignancy of the stomach and gives a good physiologic reconstruction of the gastrointestinal tract, list its many disadvantages: there is danger of leakage at the so-called deadly triangle; it is difficult to bring the duodenal end to the gastric stump if the resection has been wide; there is danger of tension on the duodenum; if carcinoma recurs locally, it may cause pyloric obstruction, a complication that is less frequent in the modifications of Billroth's second operation; and there is too great a tendency for the surgeon to be conservative in the amount of stomach removed, making resection worse than useless in all but very early and very small lesions. The surgeon obviously must meet the requirement of removing not only the involved lymph glands, but also a liberal portion of apparently normal gastric wall, to be certain that all tumor cells which may have extended within the wall of the stomach are removed. The disadvantages of this operation are so much better known than its advantages that it has less frequent use than it deserves.

The majority of resections for carcinoma of the stomach, however, are carried out by some technique which anastomoses part or all of the open end of the gastric remnant to the jejunum. The chief differences in technique depend upon whether or not the jejunum is brought anterior to the transverse colon or posterior through the mesocolon, or whether the full gastric stump or only a portion of it is used for the anastomosis. Pack and Scharnagel[67] believe that the Billroth II modification permits a wider resection with less danger of leakage, and that it can be performed more quickly and in two stages when necessary. In addition, they believe that the Hoffmeister-Finsterer type of anastomosis, which requires a shorter jejunal loop than the typical Polya, lessens the opportunity for kinking and eliminates the fear of too rapid emptying of the stomach. Lewisohn and Mage also prefer the Billroth II operation because it facilitates a wide resection. Balfour[6] favors the Billroth II method of resection, since, when recurrence takes place after this operation, mechanical difficulties are infrequent.

Marshall[52] favors the Hoffmeister modification of the Polya procedure, bringing the jejunum up anterior to the transverse colon. A liberal loop of jejunum at least 25 cm. in length is used between the anastomosis and the ligament of Treitz. Many believe it makes little difference whether the proximal or distal loop of the jejunum is at the greater curvature, since good results are obtained with either method. The jejunum may be brought up through the transverse mesocolon posterior to the colon when the mesenteric omentum is quite fat or when the mesentery of the jejunum is very short. Walters[91] prefers an anastomosis posterior to the colon, using a short loop of proximal jejunum. If the transverse mesocolon is thick, he advocates the Polya-Balfour type anterior to the colon. A point 30 cm. from the ligament of Treitz is chosen, and an enteroanastomosis is carried out with a stoma 4 to 5 cm. in diameter, since the proximal loop distends in about one-third of the cases, demanding enteroanastomosis later if this is not done at the time. Marshall,[52] on the other hand, does not believe that an enteroenterostomy is necessary when the resection is antecolic. There is no contraindication to the enteroenterostomy following resection for malignancy, although it is very definitely contraindicated when such a resection is carried out for ulcer, because of the danger of marginal ulceration. Allen[2] likewise prefers the posterior type of Polya anastomosis.

Lahey and Jordan describe a technical procedure of dividing the ligament of Treitz, permitting the transplantation of the proximal loop of jejunum entirely above the transverse mesocolon. This prevents the danger of hernia and avoids angulation of the proximal loop of bowel. They report its successful employment in twenty cases. Lahey, Swinton, and Peelen describe the technique of anastomosing the jejunum to the posterior wall of the stomach, then incising through the muscularis, and tying the individual vessels in the gastric mucosa beneath the muscularis. The anastomosis is completed without the use of clamps. The majority of surgeons routinely apply a crushing clamp similar to a Payr clamp with division of the stomach by actual cautery with or without closure of part or all of the gastric opening with silk or catgut sutures. Cutler and Zollinger[21] recommend the universal use of silk suture material in gastric surgery, with interrupted silk to the serosa and a continuous silk suture to the mucosa.

The technical steps of the operation are shortened by the use of some form of mechanical sewing clamp as advocated by Pack and Scharnagel.[66] They believe that the dePetz clamp, for example, gives greatest assurance against spilling the gastric contents; produces absolute hemostasis, making the application of one layer of sutures very rapid; and at the same time allows correct approximation of the wound edges without tension. The only difficulty which they point out is that it may not be applicable in very high resections. Marshall,[52]

likewise, closes the gastric remnant with a mechanical sewing clamp and then excises the portion at the greater curvature to provide a stoma for anastomosis to the jejunum.

The mortality following gastric resection for carcinoma is definitely higher than that following resection for ulcer. Balfour[6] reports a mortality for resection between 10 and 13.9 per cent; Lewisohn and Mage, 33 per cent; Finsterer, 10 per cent (estimated); Marshall and Taylor, 31 per cent; Marti, 19.1 per cent. Gray and Balfour believe that the mortality following partial gastrectomy should be close to 10 per cent. It is difficult to compare reports on mortality because the figure no doubt varies with the type of case available for operation, the definition of operability, and other factors. The distressing part of the entire situation is the relatively small number of patients who come to surgery early enough to have a subtotal resection for a lesion limited to the stomach.

A small number of patients may expect a survival period of five or more years following subtotal gastrectomy. Lewisohn and Mage, in following up 88 patients over a ten-year period, find 10 well for five years or more following resection, 3 of whom had a survival period of more than ten years. Only 2 of this group were below the age of 50 years at the time of operation. Bull states that patients with carcinoma of the stomach who undergo resection have an average life extension five to six times longer than the patients with carcinoma of the stomach who do not, and he urges that at operation every effort be made to perform resection. Finsterer gives the incidence of permanent cure as between 22.2 and 27.6 per cent in cases having resection, the lower figure applying to cases of ulcer carcinoma. Lahey, Swinton, and Peelen report 1 man alive and well twelve years after radical resection. Marti states that, of 32 males undergoing gastric resection at least five years previously, 6 are still living; and of 25 females, 8 are living. Parsons and Welch say that 20 per cent of the patients in their series who underwent resection survived five years. Thiesen, in surveying a group of 184 patients in whom three-quarters or more of the stomach was resected, finds that 33, or almost 18 per cent, were living and well after five or more years. Sixteen, or almost one-half of the patients living at this time, had involved lymph nodes at the time of operation. When the growth and lymph nodes can be excised, there is a 30 per cent chance of a five-year cure, a 48 per cent chance when lymph nodes are not involved, and an 18 per cent chance when lymph nodes are involved.[91] Balfour[5] believes that Broder's grading of malignant tumors is a most important prognostic factor. Patients having lesions of a microscopic grading of I and II show a 63 per cent survival after five years and 55 per cent after ten years; those with a grading of III or IV show only a 20 per cent survival after five years. Livingston and Pack, from a study of 14,000 cases of gastric cancer, conclude

that the degree of success following resection exceeds that attained in the care of any form of strictly internal cancer and approximates or equals that obtained in the management of many external or readily accessible varieties of malignant tumors.

The survival period, therefore, depends not so much on the size of the tumor as it does on the location and presence of glandular metastasis and, like tumors elsewhere, on the rapidity of cell growth.

POSTOPERATIVE CARE

The avoidance of shock and pulmonary complications is the primary concern in the postoperative care of the gastric case. If blood loss has been great, immediate transfusion is given, although some surgeons prefer to give 500 c.c. of citrated blood during the operation. The position of the patient is changed frequently; the lungs are hyperventilated with carbon dioxide. In addition, after a prolonged gastric operation, Marshall advocates the use of an oxygen tent. The respiratory rate should not be cut down too much by morphine; nor should the abdominal binder be tight enough to hinder free excursion. Postoperative atelectasis may be relieved by aspiration through a bronchoscope.

Constant gastric suction is resumed through the Levine tube, which is often left in place during the operation. Water in sips is allowed after twenty-four hours. The fluid balance is maintained by intravenous or subcutaneous administration of 5 per cent dextrose in amounts up to 3,000 c.c. a day. With adequate fluid intake, the urinary output will be at least 1,000 c.c. a day. If edema develops, chloride and serum protein determinations are made; distilled water is substituted for saline solution; and a low protein level is raised by transfusion. The diet is slowly increased in accordance with the Sippy regimen. Solid food is withheld until the fourteenth or fifteenth day. Should there be a tendency to vomit, constant gastric suction is resumed and maintained for as long as is necessary. For several months after extensive resection the patient is advised to eat five small meals a day, with a gradual return to the usual three.

TOTAL GASTRECTOMY

The removal of the entire stomach in an attempt to eradicate malignant disease located near the esophagus is occasionally justifiable. Although relatively few successful cases of total gastrectomy have been reported, the records of most large clinics probably show one or more survivors of this operation. It is obviously an operation of great magnitude with resultant high mortality.

Total gastrectomy may be advisable for a malignant lesion, located high in the fundus and confined entirely to the stomach. The esophagus should show no involvement by x-ray examination or esophagoscopy; neither should there be evidence of metastasis. As pointed out by Allen,[3] the thin, ptotic individual with a short anteroposterior diameter

of the body is a more suitable patient for this procedure than the heavy, barrel-chested person. But in any case, the general condition of the patient must offer reasonable assurance of a successful outcome or total gastrectomy should not be attempted.

The preoperative preparation of the patient for total gastrectomy should follow the same routine as for subtotal resection, including the usual gastric lavages of dilute hydrochloric acid. Before the anesthesia is started, a Levine tube may be inserted into the stomach, permitting suction as desired during the resection. This serves to prevent soiling of the operative field and lowers the incidence of subsequent peritonitis.[2] At the completion of the anastomosis the Levine tube is directed down the distal arm of the jejunum, to remain in place during the early days of the postoperative period. At least 1,000 to 1,500 c.c. of blood must be available for transfusion. Because of the high incidence of postoperative pulmonary complications following gastrectomy, it is essential that the patient be free of respiratory infection.

If a general anesthetic is to be used, its administration through an intratracheal apparatus with a closed machine is advisable.

The abdomen is explored through a left rectus incision. If a total gastrectomy is indicated, the left rectus incision is carried well up to the xiphocostal angle. In such instances Clute and Albright[15] advocate the mobilization of the left lower costal outlet by cutting the sixth and seventh costal cartilages. It should be re-emphasized that the surgeon, before attempting total gastrectomy, should be certain that there is no involvement of the lower end of the esophagus, making it impossible to mobilize and use it for anastomosis.[14] This point should be determined before the duodenum is divided and the entire blood supply to the stomach is resected. If the esophagus is involved, the thoracic approach, as successfully followed by Marshall,[51] may be advisable.

At operation the tumor involvement may not be as extensive as it first appeared, and it may be possible to leave a rim of stomach attached to the esophagus to complete the anastomosis. Every effort should be made to save a margin of stomach, if possible, since the mortality rate is much lower if the anastomosis is done to a small gastric remnant than to the esophagus.[2] When any stomach at all, even an inch, remains, the operation cannot be classed as a total gastrectomy.

After the duodenal stump has been closed and the blood supply to the stomach has been clamped and tied, attention is directed toward exposure and preparation of the esophagus for anastomosis. The mortality is perhaps related to the amount of esophagus that can be exposed in each patient, because adequate exposure facilitates the anastomosis and avoids subsequent tension on the suture line. Turner's suggestion of dividing the diaphragmatic attachment of the left lobe of the liver has met general approval, for it permits retraction of the liver medially, thereby affording better exposure to the cardia and lower esophagus.[2]

Lahey emphasizes the importance of dissecting a peritoneal flap, both anterior and posterior to the esophagus, to which the jejunum may be subsequently anchored, thereby relieving the suture line of the weight of the long jejunal loop with its attached mesentery. Further exposure of the esophagus is obtained, as pointed out by Allen,[2] by sectioning the vagus nerve until 2 to 6 cm. of the esophagus can be exposed.

Several methods of lessening the technical difficulties encountered in anastomosing the jejunum to the esophagus have been presented. Lahey and Walters[24] prefer to use the stomach as a tractor until the posterior layer of sutures between the esophagus and jejunum has been placed. A long loop of jejunum is selected which, by repeated trial, shows a mesentery sufficiently long to permit anastomosis to the esophagus without increased tension. This loop of jejunum is brought up anterior to the transverse colon after the placement of the initial layer of sutures. The esophagus is opened on its posterior wall, and an opening of similar size is made in the jejunum. The posterior mucosal layer of sutures is now placed before the anterior wall of the esophagus is finally divided and the specimen is removed. Allen,[2] on the other hand, removes the stomach and applies long right-angle clamps to the region of the esophagus, with traction sutures on either angle. Following Roeder's suggestion, he sews the jejunum to the diaphragm posteriorly, and finally anteriorly, to insure complete anchorage about the stoma and to prevent tension on the suture line. He prefers to use an enteroenterostomy at the base of the two arms of the jejunum with a Witzel enterostomy into the jejunum distal to the enteroenterostomy, while Lahey believes this is unnecessary.

Although successful total gastrectomies have been carried out by anastomosing the duodenum to the esophagus, Allen[2] clearly shows that this is an undesirable technique because of the high mortality which results.

The operative mortality of total gastrectomy is difficult to evaluate, because most clinics report only successful cases. On the average, it is probably in the neighborhood of 50 per cent, although a few individual surgeons have shown an improvement over this figure. Holst reports 7 cases of total gastrectomy, 6 for cancer and 1 for general polyposis with diffuse bleeding. The patient with polyposis was in good condition two and one-half years after operation and was able to work; and 1 of the cancer patients was living fifteen months after operation and had gained 10 kg. Walters[24] reports 20 patients with total gastrectomy, 4 of whom lived from two to three and one-half years. Allen,[2] in a series of 16 patients with total gastrectomy, states that of the 8 survivors 5 are now living. One of these 5 has lived four and one-half years after operation without recurrence of symptoms. Lahey reports 1 patient living three and one-half years after total gastrectomy.

Food by mouth is withheld until the fourth day following operation, when gruels and liquids are started. Small feedings of readily tolerated foods are gradually added, until by the fifteenth day the patient is getting five small meals a day. Concentrated, high caloric foods should not be given, for these frequently initiate diarrhea. The diet of patients following total gastrectomy requires considerable attention until the jejunum has dilated to act as a reservoir for food.

Some patients are benefited by the administration of small doses of hydrochloric acid. In addition, the patient will probably profit from moderate doses of iron, although the clinical picture of pernicious anemia has not been emphasized by those reporting this operation. Tateno reports 3 patients with total gastrectomy who survived from 135 to 193 days after operation, in 2 of whom general weakness and hypoplastic, hyperchromic anemia developed.

Holst concludes that the nutrition absorption of the intestinal canal is only slightly affected after gastrectomy. It is apparent, therefore, that a patient can get along fairly satisfactorily without a stomach, with only a moderate restriction as to the frequency and size of regular meals.

FREE PERFORATION OF GASTRIC CARCINOMA

In rare instances (4 per cent) carcinoma of the stomach may result in a free perforation.[56] As Aird points out from studying 71 such cases collected from the literature, two-thirds of the cases resemble a perforated ulcer. In one-third of the cases the perforation is more or less silent with little pain and perhaps slight abdominal rigidity. McNealy and Hedin report that a correct diagnosis was made in but 31.6 per cent of their cases before operation. They also add that, while carcinoma of the stomach may perforate irrespective of the location of the lesion, the lesser curvature, the prepyloric region, and the cardiac end were the most common sites of perforation in their series. They urge routine biopsy of all perforated gastric ulcers, for at the time the perforation is closed it is often difficult to determine whether or not the lesion is malignant without microscopic examination.

Patients with perforated carcinoma of the stomach are usually poor risks for surgery (mortality 50 to 60 per cent), many of whom can survive only the minimum of surgery.[1, 22] Therefore, simple closure of the perforation with or without gastroenterostomy is probably the safest immediate treatment. Since the aim of surgery is to remove the carcinomatous lesion, if possible, simple closure should be followed by resection when the condition of the patient will permit. Peritonitis may occur in association with carcinoma of the stomach without actual free perforation.[1] Fifty per cent of the reported cases showed metastasis at the time of perforation.[1] Brunschwig and Heinz emphasize conservative management with simple closure of the perfora-

tion to be followed by a partial gastrectomy after the patient has recovered. Resection should not be delayed too long after closure. Fleming reports a case of perforated gastric carcinoma in which the area about the perforation was cauterized and the opening was closed with through-and-through sutures, with inversion of the stomach wall. Two weeks later a partial gastrectomy was performed, with recovery of the patient.

BENIGN TUMORS

Benign tumors of the stomach are relatively rare, the incidence, according to Eusterman and Balfour, being 1 benign tumor to 200 malignant tumors. Hunt[32] concludes that benign lesions make up 0.5 to 5 per cent of all gastric neoplasms. Minnes and Geschickter state that approximately 5 per cent of gastric tumors are benign. They collected 931 benign tumors from the literature and divided these into four groups: 35.2 per cent, epithelial; 55.9 per cent, mesenchymal; 4.3 per cent, endothelial; and 4.1 per cent, cysts. Gray and Wood collected 10 cystic tumors of the stomach from the literature and 3 from the files of the Mayo Clinic.

The diagnosis of benign lesion of the stomach is usually made by roentgenologic examination and may be suspected if there is an unexplained anemia. The anemia, however, may progress until it strongly suggests pernicious anemia. Therefore, Priestley and Heck urge that in all cases of primary anemia the stomach be carefully examined by x-ray. Dyspepsia in some form is reported in 20 per cent of the cases; pyloric obstruction, usually intermittent, occurs in 10 per cent.[24] McLaughlin and Conlin discuss at length pedunculated gastric tumors. They found 10 to 20 per cent of benign gastric neoplasms develop on pedicles and can produce pyloric obstruction. They also state that 30 to 40 per cent of pedunculated tumors in the stomach show malignant degeneration.

Because of their tendency to undergo malignant degeneration, benign tumors should be resected.[33] Balfour[6] believes that, when a tumor which has been bleeding is visualized by x-ray, it should be removed, because a considerable percentage of such tumors are either polyps of a low degree malignancy or they may become so. Chamberlin believes that a gastric polyp, although rarely encountered, is potentially a precursor of carcinoma and should be removed at once. During a study of 7,000 autopsies, Lawrence found 50 polyps, 18 per cent of which were malignant and over 50 per cent of which were multiple. The finding of multiple tumors at the time of operation should not be unexpected, although only a single lesion has been demonstrated by x-ray.[6]

Local excision of the growth may be all that is necessary, unless there is microscopic evidence of malignancy. Chaffin reports that local excision of benign tumors gives as good an end result as extensive

resection and carries a lower mortality. McLaughlin and Conlin advise partial gastrectomy. The type of surgery carried out will depend upon the extent of the lesion, its location, and its probable chance of being malignant.[33]

SARCOMA

Sarcomas are uncommon and probably constitute not over 1 per cent of gastric malignancies.[63] Counseller and Collins report that, of 4,733 cases of carcinoma of the stomach coming to surgery, 72 were sarcomas. Pack and McNeer[63] report 9 sarcomas of the stomach, which included 4 myxosarcomas, 3 primary lymphosarcomas, and 2 cases of general lymphosarcomatosis with secondary involvement of the stomach. Taylor estimates that 40 to 50 per cent of all gastric sarcomas are lymphosarcoma. He was able to collect 147 cases of primary lymphosarcoma from the literature, and added 5 new cases.

Sarcoma usually occurs in patients ten to fifteen years younger than those with gastric carcinoma.[24] The average duration of symptoms for gastric sarcoma is about eighteen months, but may range from six months to nine years.[24] Almost one-half the patients present themselves with an epigastric tumor, commonly situated in the antrum, as the chief complaint.[24] Obstruction, though, is rare. There apparently are no pathognomonic, clinical, or roentgenologic findings, although gastroscopy may prove of value.[88]

In general, resection appears to be the ideal procedure and should be planned if it is at all possible.[63] If this is not possible, well-planned irradiation therapy should be employed. In cases of myosarcoma and neurosarcoma, radiation therapy may not be of great value, but it is always indicated in cases of primary gastric lymphosarcoma, with beneficial and even curative results following.[63] The lymphosarcomas respond extremely well to radiation. Therefore, if a diagnosis of lymphosarcoma is suspected in a lesion which would carry a high risk if resection were carried out, this suspicion should be confirmed by biopsy, and radiation rather than resection should be advocated. Taylor remarks that thirteen patients with lymphosarcoma of the stomach have lived five to twenty-two years since the lesion was discovered, and emphasizes the desirability of establishing a histologic diagnosis of gastric neoplasm, regardless of how extensive the lesion may be, in order to insure the patient with lymphosarcoma the benefits of irradiation.

IRRADIATION THERAPY

Since less than one in twenty gastric neoplasms are radiosensitive, irradiation is but rarely used in the treatment of carcinoma of the stomach.[68] The initial response of cancer of the lesser curvature to irradiation is the best of any of the regional distributions, yet the rate of survival for periods over one year is less than that obtained for cancer of the pars media, fundus, and cardia.[64]

Lesions about the cardia are often difficult to diagnose. Kiefer, after studying 28 cases, found that there was no difference in the first symptoms from those of gastric malignancy in general. Stenström was able to diagnose by x-ray 38 cases of carcinoma of the fundus of the stomach in 300 cases of gastric cancer studied at the Maria Hospital, Stockholm.

Watson advocates the use of a Janeway gastrostomy in the treatment of lesions of the cardia and the esophagus. At the time that the gastrostomy is done, a biopsy is obtained. Through a small esophagoscope inserted through the gastric opening, the size of the lesion can be determined, permitting a better estimate of the dose of gold-filtered radon seeds necessary to control the lesion. By weekly gastroscopy through the gastrostomy stoma, the radium reaction may be followed, a checkup biopsy may be taken, and more radon seeds implanted if necessary.

Pack and his associates[68] feel that radon element packs are most effective for external irradiation of gastric carcinoma. Before treatment, however, the stomach should be thoroughly washed to avoid infection from the massive necrosis which follows irradiation. Preoperative irradiation is not recommended except in two-stage resections, when treatment may be given after gastroenterostomy and exclusion of the distal segment. Neither is prophylactic irradiation after radical resection advised as a routine procedure. They report four cases, with a survival period of two to seven years following the initial irradiation. Kaplan reports irradiation in three cases after a preliminary gastroenterostomy. The stomach was delivered into the wound. Twenty to forty radon seeds, containing 1 mc. of radon each, were implanted into the lesion. After the wound had healed, high voltage x-ray treatments, directed anteriorly and posteriorly, were given. Two of these tumors were pyloric and responded well to treatment. Strauss describes the use of surgical diathermy following a technique similar to that which he has advocated in cancer of the rectum. After a Witzel jejunostomy, the anterior wall of the stomach is sutured to the skin and an opening is made between the lesser and greater curvatures. The tumor is then coagulated by means of a special gastroscope. The efficiency of this treatment cannot be determined, since no late results have been recorded. Baum reports a patient with carcinoma involving the lower esophagus and cardiac portion of the stomach who lived for six years following high voltage x-ray therapy, which extended over a period of sixty-nine days.

Neither irradiation nor surgical therapy can offer more than meager hope to the patient with carcinomatous involvement of the cardiac end of the stomach.[35]

SUMMARY

1. Unfortunately there is no chain of symptoms characteristic of early carcinoma of the stomach. For this reason it would seem that, if

earlier diagnosis is to be possible, any patient with persistent gastrointestinal complaints, regardless of how slight they may be, should have gastrointestinal barium studies. The average duration of symptoms before operation is eight to twelve months.

2. Every gastric ulcer should be considered potentially malignant. Patients with gastric ulcer should be placed on a rigid dietary regimen and should have frequent x-ray examination, regardless of early, apparent response to treatment. Gastric ulcers in the prepyloric inch and on the greater curvature, large gastric ulcers, and ulcers that do not respond to medical treatment within three weeks should be treated as malignant lesions.

3. Any patient with carcinoma of the stomach deserves exploration, irrespective of the size of the tumor, unless there is clear-cut evidence of distant metastasis.

4. Peritoneoscopy appears to be of value. Through its use, unnecessary exploratory operations may be avoided.

5. A rigid preoperative preparation, with special effort directed toward cleansing the stomach, is essential to reduce mortality from infection.

6. When first seen, approximately 75 per cent of the patients with gastric carcinoma harbor an unresectable tumor.

7. A palliative resection may be justifiable, even in the presence of limited metastasis. The Devine exclusion operation or gastroenterostomy is most commonly used. Short-circuiting operations in far advanced cases may fail to give symptomatic relief.

8. Microscopic studies show carcinomatous involvement of the tissues beyond the gross limits of the tumor for a distance of 2.3 cm. in the duodenal wall and for as much as 7 cm. in the gastric wall. Whenever possible, removal of gastric or duodenal wall well beyond the limits of the tumor is essential.

9. The number of successful subtotal and total gastrectomies is increasing.

10. The mortality for gastric resection for cancer is higher than that for ulcer and varies between 10 and 30 per cent. Palliative operations and exploration likewise have a high mortality rate.

11. The complications after gastric operations are about evenly divided among pulmonary complications, infections, and a miscellaneous group.

12. The average length of life after palliative operations is approximately four to six months. Five-year survival after gastrectomy is recorded in from 20 to 30 per cent of the cases.

13. One case in twenty of gastric carcinoma will respond to irradiation. Cases of lymphosarcoma respond well, and long survivals are recorded.

14. The so-called benign tumor of the stomach tends to produce secondary anemia and to undergo malignant degeneration (30 to 40 per cent). Such tumors should be excised.

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Book Reviews

The Hospital Care of Neurosurgical Patients. By Wallace B. Hamby, M.D. Cloth. Pp. 118, with 24 illustrations. Springfield, Ill., 1939, Charles C. Thomas, Publisher. $2.

This book, which was written for nurses and the young physician, should meet a need by collecting in a small monograph material which is nowhere else to be found in any single treatise.

It gives in simple form essential anatomy; a description of the procedures that are peculiar to neurosurgery, such as spinal puncture, Quackenstedt test, injection of iodized oil, encephalography, ventriculography, etc.; and a description of such procedures as catheterization, vena puncture, and transfusion which are common to all types of surgery.

In a most simplified form it describes the whole range of common neurosurgical conditions and gives the treatment of each. Preparation of the patient for operation, postoperative care, and complications are treated in a clear and concise manner.

Controversial issues are passed over by a mere statement that they are controversial.

The final chapter concerns dressings of neurosurgical wounds.

It is difficult to treat a complicated subject in a simple yet inclusive manner as has been done in this book.

There are many figures, all diagrammatic line drawings, to clarify the text.

The book is recommended to answer the purpose for which it was written. Every nurses' training school should be familiar with this book, and those in hospitals caring for neurosurgical patients will find it essential to their library. It is also recommended for the neurosurgical intern.

The Neurogenic Bladder. By Frederick C. McLellan, M.D. Cloth. Pp. 206, with 57 illustrations. Springfield, Ill., and Baltimore, Md. 1939, Charles C. Thomas, Publisher. $4.

This book consists of a description of cystometry, including the apparatus used, of the innervation and function of the urinary bladder, a classification of neurogenic vesical dysfunction with description of the various types, and a series of charts of illustrative cases with cystometrograms and clinical data.

The unfavorable impression which this work has made upon the reviewer is probably due to several factors. First is the author's lack of proper reverence for the English language. For example, one cannot justify speaking of "those bladders produced by lesions of the posterior roots," however interesting such a phenomenon would be if it actually occurred.

Some of the text is practically incomprehensible: "Cerebral function in bladder control would appear to be the cerebral or supranuclear inhibition over the bladder reflex *as is seen in the adult over the infant's bladder*" (?)!

Nor can one excuse misspelling the name of a contributor to the literature in more than one way in a single book. Moreover, the diagrams of the presacral nerve (plexus) are too much idealized in that they represent a plexus as a nerve trunk.

The reviewer has devoted considerable thought and attention to the question of neurogenic vesical dysfunction (which is what the author means by "the neurogenic bladder"); nevertheless this book leaves him with a feeling of frustration and inability to understand the author's conclusions.

The author's classification is unsatisfactory in that the adjectives used to indicate the various types of dysfunction are not sufficiently descriptive and the various categories set up by him overlap too much. He distinguishes uninhibited, reflex, autonomous, and atonic types; the last certainly includes the second and third, since numerically the vast majority of cases of neurogenic vesical dysfunction are characterized by some loss of tone by the detrusor. This reviewer prefers to classify all neurogenic dysfunctions as sensory or motor, and to subdivide each of these into irritative and destructive types, chiefly because the resultant classification tells something of the behavior of the bladder as well as of the type of disease afflicting it.

There is not enough emphasis upon the role of the cystoscope both in the diagnosis of neurogenic dysfunction, in the recognition of complications, and in the differentiation of neurogenic from mechanical disturbances. It ought to be axiomatic that an indication for cystometry is also an indication for a cystoscopic examination, since the latter may reveal lesions which were unsuspected from the cystometrogram and which may be corrected surgically with relief of symptoms.

Despite these rather petulant criticisms, the book contains much of value; the charts of cystometrograms of various conditions will repay study. Still, it is a book to be read critically by someone already acquainted with the subject, rather than to be used as textual material by the uninformed.

Cirurgia do Megaesofogo. By Edmundo Vasconcelos and Gabriel Botelho. Paper. Pp. 434, with 150 illustrations. São Paulo, 1937, Companhia Editora Nacional.

Written in Portuguese, this extensive monograph is an elaborate and rather complete exposition of the subject of megoesophagus, or achalasia. Following a brief historical review of the condition, there is a detailed discussion of the various theories concerning its etiology. The authors are in accord with the generally accepted view that the condition is the result of disturbances in nerve supply of the esophagus, and present an excellent discussion of the theory and the facts supporting it. The innervation of the esophagus is clearly described. The normal physiology of the esophagus and cardia is considered in detail and the pathologic physiology in achalasia is discussed. Of particular interest is the authors' analogy between megoesophagus and megacolon. The experimental production of the disease in animals is reviewed and the authors' observations presented in details. Of interest in this regard is the possible relationship of beriberi and experimental B avitaminosis to megoesophagus, or achalasia. The characteristic clinical manifestations, the diagnosis, and the radiologic features are presented and considered in detail. The various forms of conservative and radical therapy are thoroughly discussed. The various types of operative procedures are described and the authors' experience with them is stated. The technique of these operations is illustrated by drawings which are clear and descriptive. The volume is profusely illustrated by photographs of gross and microscopic pathology, anatomical drawings, and roentgenograms. There are 627 references presented in alphabetical order which add considerably to the value of the monograph. However, it was observed that some of the original references have been omitted. The printing, which is large, well spaced, and consequently more readable, is done on heavy glazed paper.

Operative Orthopedics. By Willis C. Campbell, M.D. Pp. 1154, with 845 illustrations, 4 in color. St. Louis, 1939, The C. V. Mosby Co. $12.50.

The author's purpose can best be stated in his own words: "This volume has been written to meet the current need for a comprehensive work on operative orthopedics not only for the specialist, but also for many industrial and general surgeons who are doing excellent work in some branches of orthopedic surgery, and are making valuable contributions to this field." Everyone who has been working in the field of orthopedics recognizes the current need for such a work, and welcomes this excellent treatise by Dr. Campbell. All who have been practicing orthopedics for the past fifteen years will likewise gladly concede that no one is better prepared to write such a volume than Dr. Campbell and his associates. Those who have visited him and observed his work readily accept the truth of his statement: "In our private clinics and the hospitals with which we are associated, a sufficient amount of material on every phase of orthopedic surgery has been accumulated during the past twenty years or more to justify an evaluation of the various procedures. From this personal experience we also feel that definite conclusions may be drawn in regard to the indications, contraindications, complications, and other considerations entering into orthopedic treatment. In all surgical cases, mature judgment is required for the selection of the most appropriate procedure. With this in mind the technics which have proved most efficient in the author's experience have been given preference in the text. In addition, after a comprehensive search of the literature, operative measures have been selected which in the judgment of the author are most practicable."

This admirable text not only reviews in detail and describes with the aid of excellent illustrations the numerous operative procedures in common use in the practice of orthopedics today, but it also discusses the physiology and pathology of bones, joints, and related structures; surveys the various types of apparatus necessary to carry out and supplement operative treatment; and examines fully the subject of delayed union and nonunion of fractures.

This valuable contribution is a most welcome addition to the library of every orthopedic surgeon and will undoubtedly find its way into the reference library of all general surgeons and students contemplating corrective surgery in any of its phases.